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Ten new species of the genus *Brevisomabathynella* Cho, Park and Ranga Reddy, 2006 (Malacostraca, Bathynellacea, Parabathynellidae) from Western Australia

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Ten new species of *Brevisomabathynella* Cho, Park and Ranga Reddy, 2006 are described and illustrated from the arid region of Western Australia. Comparison of the external morphology revealed the presence of three common characters distributed among the 10 species: the five-segmented antenna, the absence of the basipodal seta on the male thoracopod VIII and the absence of a basiventral seta on the uropodal exopod. This character combination is not found in *Notobathynella* and *Billibathynella*, but only in *Brevisomabathynella*, a genus known from two described species both with unusual characters. Despite the three common attributes, the 10 new species differ remarkably from these two described species, but could not be defined by their own synapomorphy. Consequently, and cognizant of a previously performed molecular analysis, we assign the 10 new species to *Brevisomabathynella* and amend the generic diagnosis. The species inhabit shallow aquifers in groundwater calcretes and each appears to be endemic to a given calcrete formation. The two species previously known and the 10 species now described include four sympatric species pairs, with similar-sized sympatric species differing markedly in body form. *Brevisomabathynella* inhabit groundwater up to at least marine salinity.

Keywords: *Brevisomabathynella*; Parabathynellidae; new species; Yilgarn; Western Australia; Australia

Introduction

The subterranean biotopes of the arid region of Western Australia are proving to be remarkably rich in bathynellacean fauna. The fauna continues to surprise, not only in terms of species diversity, but also in the various morphological novelties: fat-bellied, massive head (Cho, Humphreys and Lee 2006; Cho, Park and Ranga Reddy 2006; this paper), massive body size (Cho 2005), trophic position (predator, Cho, Park and Ranga Reddy 2006), highly saline environments (Humphreys et al. 2009) and mid-water activity. In the last 4 years, 18 species of Parabathynellidae Noodt, 1964 in four genera (*Atopobathynella* Schminke, 1973; *Billibathynella* Cho, 2005; *Kimberleybathynella* Cho et al., 2005; *Brevisomabathynella* Cho et al., 2006) have been described from this region (Hong and Cho 2009), the latter three genera being endemic to Australia. As noted by Guzik et al. (2008), the continuing study of the fauna from this

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region promises to yield a significant extension to our knowledge of the taxonomy and geographic extent of Parabathynellidae. As one of the interim results, this paper describes 10 new species which, despite their great morphological diversity, are assigned to *Brevisomabathynella*, currently including two species.

Materials and methods

The material was collected from hand-dug pastoral wells, tube wells and mineral exploration bores, using haul-nets (250- or 350-μm mesh). Haul-nets are simple plankton nets of different sizes (30- to 350-mm diameter) suitable for the sample sites. A weighted net with a vial screwed onto its caudal end was lowered into wells and then hauled through the water column several times, also stirring the sediment. The wells typically have bare calcrete near the floor, but may have an upper lining of timber or concrete. Tube wells are typically cased with PVC pipes, slotted to allow ingress of water into the tube, whereas mineral exploration bores lack any casing. A description of the typical calcrete habitat is provided by Humphreys (1999, 2001).

Samples were prepared and mounted in a mixture of glycerin–formalin. For drawing and investigation, a Nikon Eclipse E600 microscope with differential interference contrast equipment was used with oil immersion. The type material of the new species herein described, as permanent slide preparations, is deposited in the collection of the Western Australian Museum, Perth (WAM).

Water quality was determined using a Quanta-G (Hydrolab Corporation, Austin, TX, USA) water-quality-monitoring system attached to a 50-m cable, which permitted the measurement of various physicochemical water-quality parameters (temperature, specific conductance (or TDS), pH, dissolved oxygen, oxidation reduction potential (redox), and depth, the latter facilitating the determination of any vertical stratification in the water column in some boreholes, as used by Watts and Humphreys (2004). The instrument was calibrated against the standards recommended for the instrument.

Systematics

Family **PARABATHYNELLIDAE** Noodt, 1964
Brevisomabathynella Cho, Park and Ranga Reddy, 2006

Revised diagnosis

Parabathynellidae. Body elongated or short and cylindrical or fat-bellied. Antennule seven-segmented. Antenna five-segmented. Labrum flat with numerous teeth on free margin. Mandibular palp one-segmented. Maxilla four-segmented. Thoracopods I–VII with exopod of two and more (2–12) segments. Male thoracopod VIII almost rectangular or oval, longer than wide; protopod protrudes at inner distal corner; epipod large, triangular, distal part covering penial region of protopod; basipod without setae, inner margin of basipod drawn out into projection. Uropod with numerous (6–20) spines on sympod; endopod with two terminal spines, one or two plumose setae near base, three terminal setae, protrusion on disto-outer margin, inner spines variable in number; exopod with numerous setae, without basiventral seta.

Anal operculum flat to slightly concave. Furcal rami elongated, with two large terminal spines and numerous (5–20) spines on inner margin.

***Brevisomabathynella magna* sp. nov.**
(Figures 1–4)

Material examined

Holotype (adult male), allotype (adult female), paratypes (two adult males and three adult females). Holotype: dissected on five slides (WAM C 40072). Allotype dissected on five slides (WAM C 40073). One male and one female paratype each dissected on five slides; one male and two female paratypes each as a whole specimen on separate slides (WAM C 40074 – C 40078).

Type locality

Australia, Western Australia, Nabberu Palaeodrainage, Cunyu Station Site 272 Sweetwaters-Well (25°36′38″ S, 120°22′21″ E), BES 8158, 23 August 2001, leg. W.F. Humphreys, T. Karanovic and J.M. Waldock.

Description of adult male (holotype)

Body. Length 4.62 mm. Elongated and cylindrical, approximately 10 times as long as wide. Head as long as anterior three thoracic segments combined (Figure 1A,B).

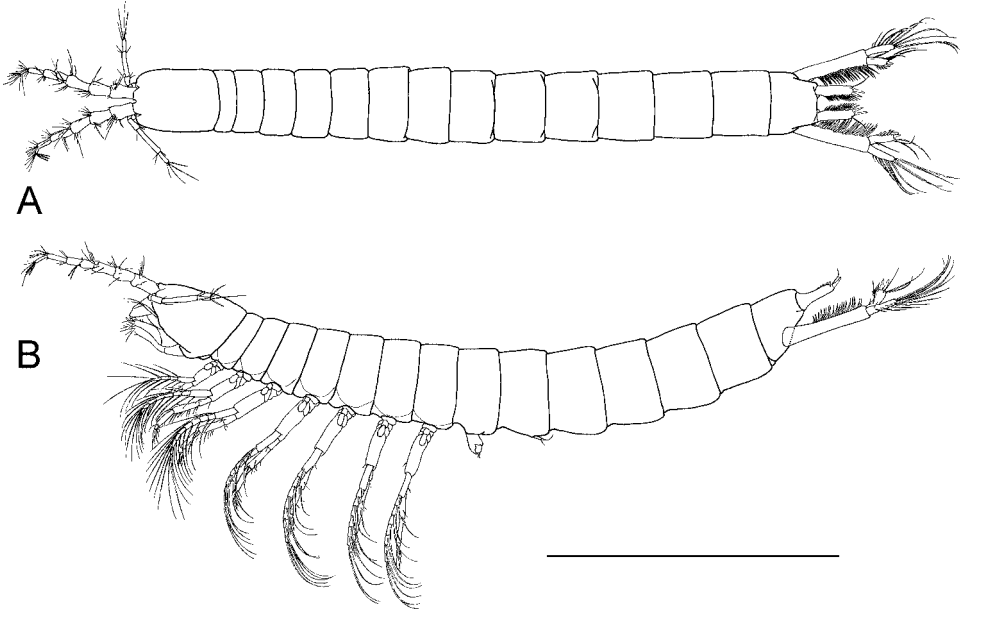

Figure 1. General habitus of *Brevisomabathynella magna* sp. nov. (♂, holotype): (A) dorsal; (B) lateral. Scale bar 2 mm.

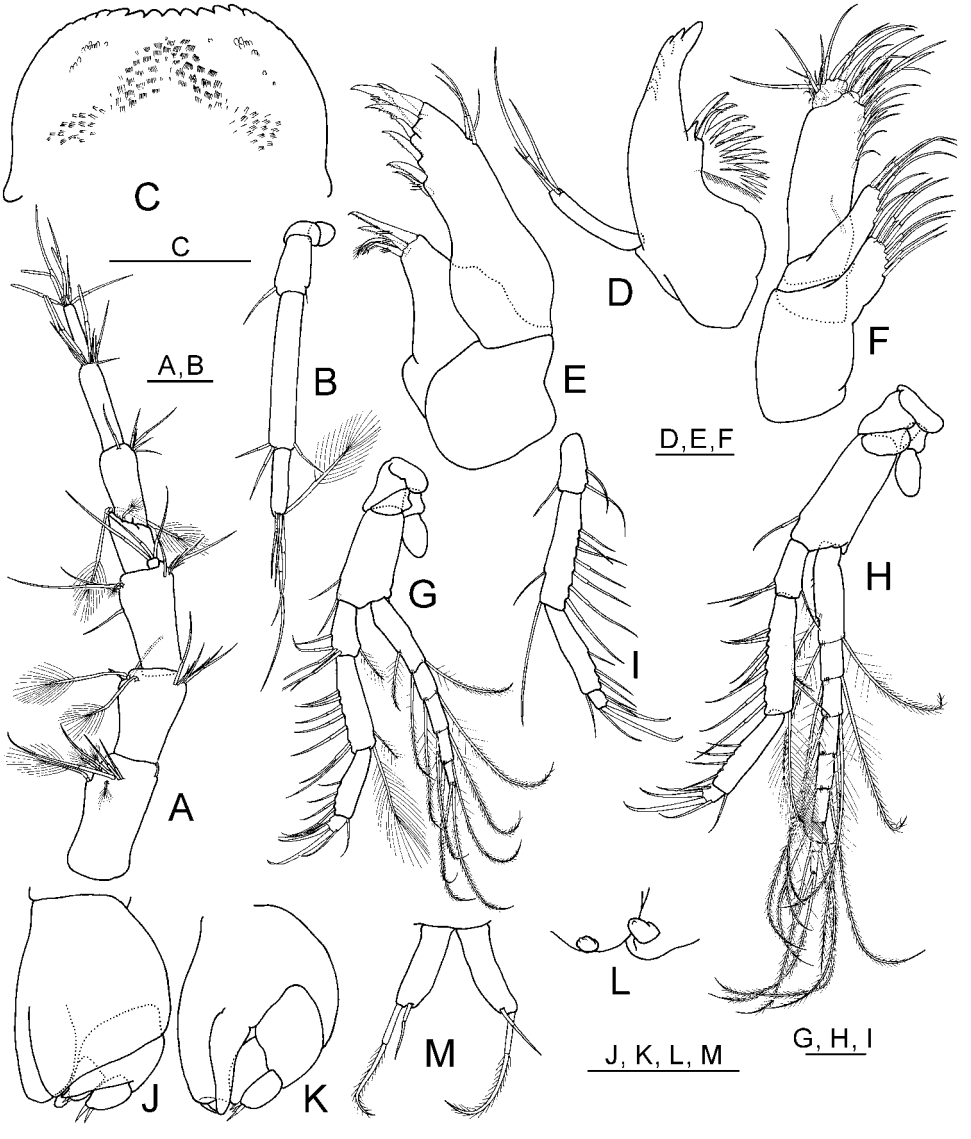

Figure 2. *Brevisomabathynella magna* sp. nov. (♂, holotype; ♀, allotype): (A) left antennule ♂ (dorsal); (B) left antenna ♂ (dorsal); (C) labrum ♂ (ventral); (D) right mandible ♂ (ventral); (E) left maxillule I ♂ (ventral); (F) left maxilla II ♂ (dorsal); (G) left thoracopod I ♂ (frontal); (H) left thoracopod II ♂ (frontal); (I) endopod of right thoracopod II ♂ (frontal); (J) right thoracopod VIII ♂ (inner lateral); (K) left thoracopod VIII ♂ (outer lateral); (L) right and left thoracopods VIII ♀ (ventral); (M) right and left pleopods I ♂ (ventral). Scale bars 0.1 mm.

Antennule (Figure 2A). Seven-segmented. First segment with one seta on inner margin, with four simple dorsal setae and with one dorsal, one ventromedial and two lateral plumose setae. Second segment with one group of four plumose setae and with seven simple setae on inner margin. Third segment with four outer lateral setae

Figure 3. *Brevisomabathynella magna* sp. nov. (♂, holotype): (A) left thoracopod IV (frontal); (B) pleotelson, furcal rami and uropod (dorsal); (C) pleotelson, furcal rami and uropod (lateral). Scale bar 0.1 mm.

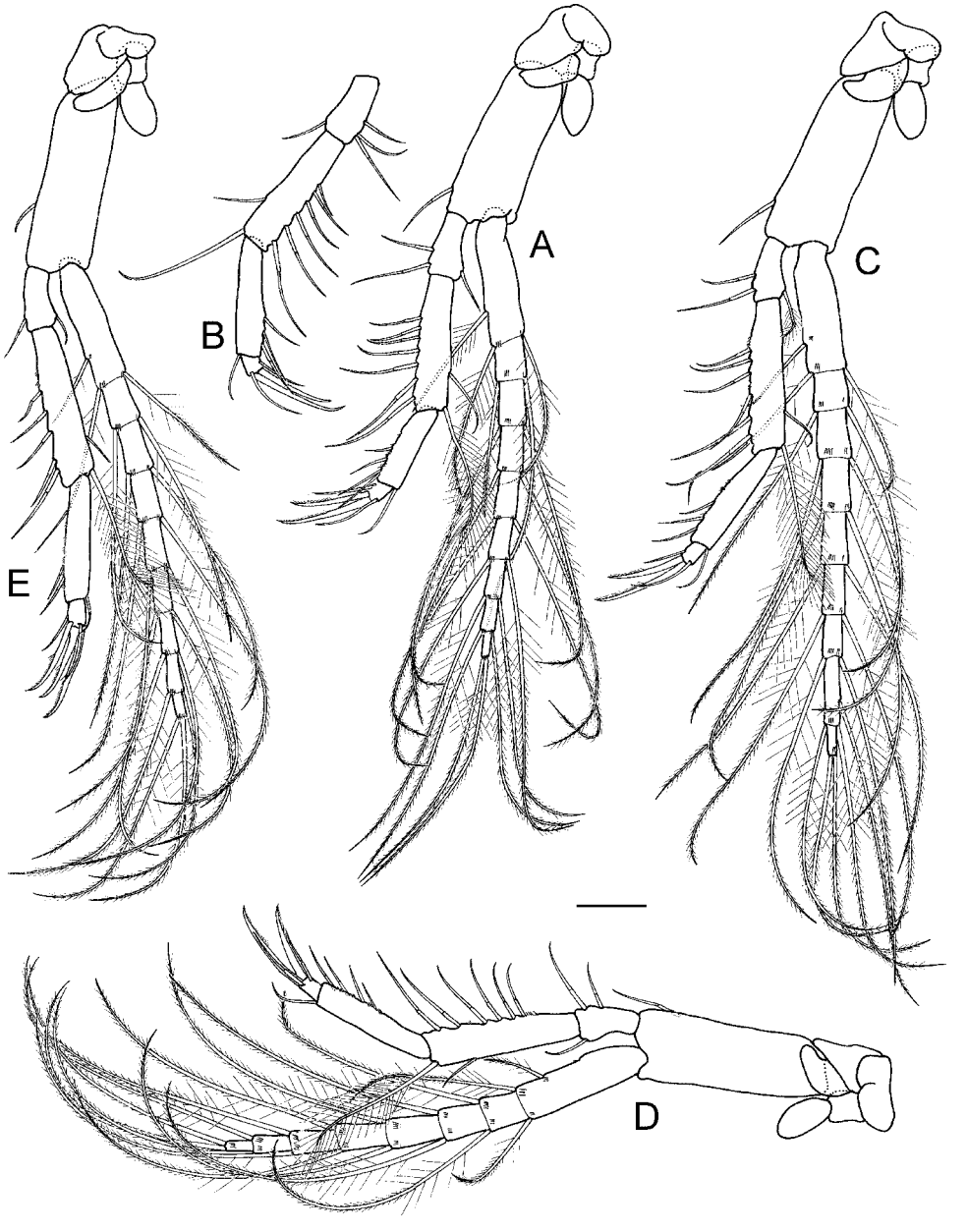

Figure 4. *Brevisomabathynella magna* sp. nov. (♂, holotype): (A) left thoracopod III (frontal); (B) endopod of right thoracopod III (frontal); (C) left thoracopod V (frontal); (D) left thoracopod VI (frontal); (E) left thoracopod VII (frontal). Scale bar 0.1 mm.

including one plumose seta and one medial simple seta, and with six setae on inner margin. Inner flagellum of third segment with three simple setae. Fourth segment with one stub seta and one plumose seta on dorsal margin, and with two stub setae and two plumose setae on outer distal apophysis. Fifth segment with five setae on

inner margin and one dorsal seta, without aesthetasc. Sixth segment with four setae on inner margin and with dorsal group of two aesthetascs, one simple seta and one additional aesthetasc lateral to simple seta. Seventh segment with three subterminal aesthetascs and four simple setae.

Antenna (Figure 2B). Five-segmented, as long as antennular segments 1–5 combined. Fourth segment over twice as long as fifth segment. Setal formula: 0+0/0+0/1+1/2+1/5(1). Plumose seta of distal segment shorter than longest simple seta.

Labrum (Figure 2C). Flat with eight median teeth of more or less similar size flanked by five smaller teeth on each side. Ventral surface with numerous combs of ctenidia and teats.

Mandible (Figure 2D). Incisor process of seven teeth. Tooth of ventral edge triangular. Spine row consisting of 13 spines. Palp of one segment, with two apical setae and one subterminal seta.

Maxillule (Figure 2E). Two-segmented. Proximal segment with four setae on inner margin. Distal segment with two terminal spines, with five spines with denticles on inner edge, and with three simple setae on outer margin.

Maxilla (Figure 2F). Four-segmented, setal formula 8-7-18-17.

Thoracopods I–VII (Figures 2G–I, 3A, 4A–D). Thoracopods I–IV increasing in size posteriorly. Thoracopods IV–VII similar in size. Thoracopods I–VII each bearing one epipod on protopod. Basipod of thoracopod I with two setae, those of thoracopods II–VII with one seta. Number of exopodal segments of thoracopods I–VII: 5-8-9-10-9,10-8-9. Endopod of thoracopods I–VII four-segmented, setal formulae:

Th. I 5+1/7+2/4+1/4(2)
Th. II 2+1/7+2/4,3+1/4(2),5(3)
Th. III 2,3+1/7,6+2/4,3+1/5(3), 4(2)
Th. IV 2+1/7+2/3+1/4(2)
Th. V 2+1/6+2/3+1/4(2)
Th. VI 2+1/6+2/4+1/4(2)
Th. VII 1+1/5+2/2+1/5(3)

Thoracopod VIII of male (Figure 2J,K). More or less oval in lateral view, 1.2 times as long as wide. Protopod massive, with prominent penial region with terminal opening. Epipod large, triangular, distal part barely reaching penial region of protopod. Basipod without setae, inner margin of basipod drawn out into projection. Exopod one-third size of basipod, triangular, bearing two subterminal setae. Endopod as long as exopod, with two terminal setae.

First pleopod (Figure 2M). In form of two stubs attached to each other basally. Each stub bearing two terminal setae.

Uropod (Figure 3B,C). Twenty spines of similar size on inner margin of sympod. Exopod 35% as long as sympod, without basiventral setae, and with 11 setae on outer and terminal margin. Endopod 29% as long as sympod, with two dorsal plumose setae near base, with two terminal setae and one subterminal plumose seta on outer margin, and with one terminal, one subterminal and three inner-marginal spines. Terminal and subterminal spines similar in size. Three inner-marginal spines spike-like, as long as terminal spine but thinner.

Pleotelson (Figure 3B,C). One seta near base of each furcal ramus on both sides. Anal operculum flat.

Furcal rami (Figure 3B,C). Four times as long as wide, with two large terminal spines, and 18 spines on inner margin, and with two dorsal setae.

Description of adult female (allotype)

Body. Length 4.42 mm. Identical to male except for following characters.

Antennule. First segment with five simple dorsal setae. Second segment with 10 simple setae on inner margin. Third segment with seven setae on inner margin. Fifth segment with four setae on inner margin.

Antenna. Setal formula: 0+0/0+0/1+1/3+1/5(1).

Thoracopods I–VII. Number of exopodal segments of thoracopods I–VII: 7-9-10-10-10-10-10. Setal formulae of endopods:

Th. I	5+1/8+2/4+1/4(2)
Th. II	2+1/7+2/4, 3+1/4(2),5(3)
Th. III, IV	2+1/7+2/4,3+1/4(2)
Th. V	2+1/7+2/2+1/4(2)
Th. VI	2+1/6+2/2+1/4(2)
Th. VII	1+1/5+2/1+1/4(2)

Thoracopod VIII (Figure 3L). Conical, half as long as endopod of male thoracopod VIII, with one terminal tooth.

Uropod. Sympod with 21 spines.

Furcal rami. Eighteen spines on inner margin.

Intraspecific variation

Range of body length: male 4.04–4.62 mm; female 4.20–4.42 mm. Variation in number of setae, spines or segments as listed in Table 1.

Etymology

The specific name refers to the large body size.

Table 1. Intraspecific variation of *Brevisomabathynella magna* sp. nov. (data acquired from the four dissected specimens).

	Holotype (♂)	Allotype (♀)	Paratype 1 (♂)	Paratype 2 (♀)
Body length (mm)	4.62	4.42	4.56	4.39
Antennule (segments)				
First segment: no. dorsal setae	4	5	4	4
Second segment: no. setae on inner distal margin	7	10	7	7
Third segment: no. setae on inner distal margin	6	7	6	6
Setal formula of maxilla	8-7-18-17	8-7-18-17	6-7-18-15	6-7-17-13
Thoracopods I–VII				
No. of exopodal segments	5-8-9-10-9,10-8-9	7-9-10-10-10-10-10	6-7-8-9-9-9-8	7-9-10-11-10-10-10
Setal formula of Th. I	5+1/7+2/4+1/4(2)	5+1/8+2/4+1/4(2)	4+1/6+2/3+1/4(2)	6+1/8+2/4+1/4(2)
Setal formula of Th. II	2+1/7+2/4,3+1/4(2),5(3)	2+1/7+2/4,3+1/4(2),5(3)	2+1/6+2/3+1/4(2)	2+1/7+2/3+1/5(3)
Setal formula of Th. III	2,3+1/7,6+2/4,3+1/5(3),4(2)	2+1/7+2/4,3+1/4(2)	2+1/6+2/3+1/4(2)	2+1/8+2/4+1/4(2)
Setal formula of Th. IV	2+1/7+2/3+1/4(2)	2+1/7+2/4,3+1/4(2)	2+1/5+2/3+1/4(2)	2+1/8+2/4+1/4(2)
Setal formula of Th. V	2+1/6+2/3+1/4(2)	2+1/7+2/2+1/4(2)	2+1/5+2/3+1/4(2)	2+1/7+2/3+1/4(2)
Setal formula of Th. VI	2+1/6+2/4+1/4(2)	2+1/6+2/2+1/4(2)	2+1/4+2/3+1/4(2)	2+1/6+2/3+1/4(2)
Setal formula of Th. VII	1+1/5+2/2+1/5(3)	1+1/5+2/1+1/4(2)	1+1/4+2/2+1/4(2)	2+1/6+2/3+1/4(2)
Uropod				
No. of spines on sympod	20	21	18	20
Furcal rami				
No. of spines on inner margin	21	18	13	19

Brevisomabathynella changjini **sp. nov.**
(Figures 5–8)

Material examined

Holotype (adult male), allotype (adult female), paratypes (five adult males and two adult females). Holotype: dissected on seven slides (WAM C 40879). Allotype: dissected on six slides (WAM C 40880). Paratypes: one male and one female each dissected on six slides, four males and one female each as a whole specimen on separate slides (WAM C 40881–C 40887).

Type locality

Australia, Western Australia, Carnegie Palaeodrainage, Lorna Glen Station Bore Site 42 (26°15′31″ S, 121°24′15″ E), BES 12875(12876), 7 April 2005, leg. W.F. Humphreys and R. Leijs.

Description of adult male (holotype)

Body. Length 4.24 mm. Elongated and cylindrical, approximately 10 times as long as wide. Head as long as anterior three thoracic segments combined.

Antennule (Figure 5A). Seven-segmented. First segment with one seta on inner margin, with four simple dorsal setae and with one dorsal, one ventromedial and two lateral plumose setae. Second segment with one group of four plumose setae and with six simple setae on inner margin. Third segment with three outer lateral setae including one plumose seta, and with five setae on inner margin. Inner flagellum of third segment with three simple setae. Fourth segment with one stub seta and one plumose seta on dorsal margin, and with two stub setae and two plumose setae on outer distal apophysis. Fifth segment with four setae on inner margin and one dorsal seta. Sixth segment with three setae on inner margin and with dorsal group of two aesthetascs, one simple seta and one additional aesthetasc lateral to simple seta. Seventh segment with three subterminal aesthetascs and four simple setae.

Antenna (Figure 5B). Five-segmented, as long as antennular segments 1–3 combined. Fourth segment as long as fifth segment. Setal formula: 0+0/0+0/1+1/2+1/4(1). Plumose seta of distal segment shorter than longest simple seta.

Labrum (Figure 5C). Flat with 12 median teeth of more or less similar size flanked by four (left) or five (right) teeth decreasing in size laterally on each side. Ventral surface with numerous combs of ctenidia and teats.

Mandible (Figure 5D). Incisor process of seven teeth. Tooth of ventral edge triangular. Spine row consisting of 12 spines. Palp of one segment, with one apical seta.

Maxillule (Figure 5E). Two-segmented. Proximal segment with four setae on inner margin. Distal segment with two terminal spines, with five spines with denticles on inner edge, and with three simple setae on outer margin.

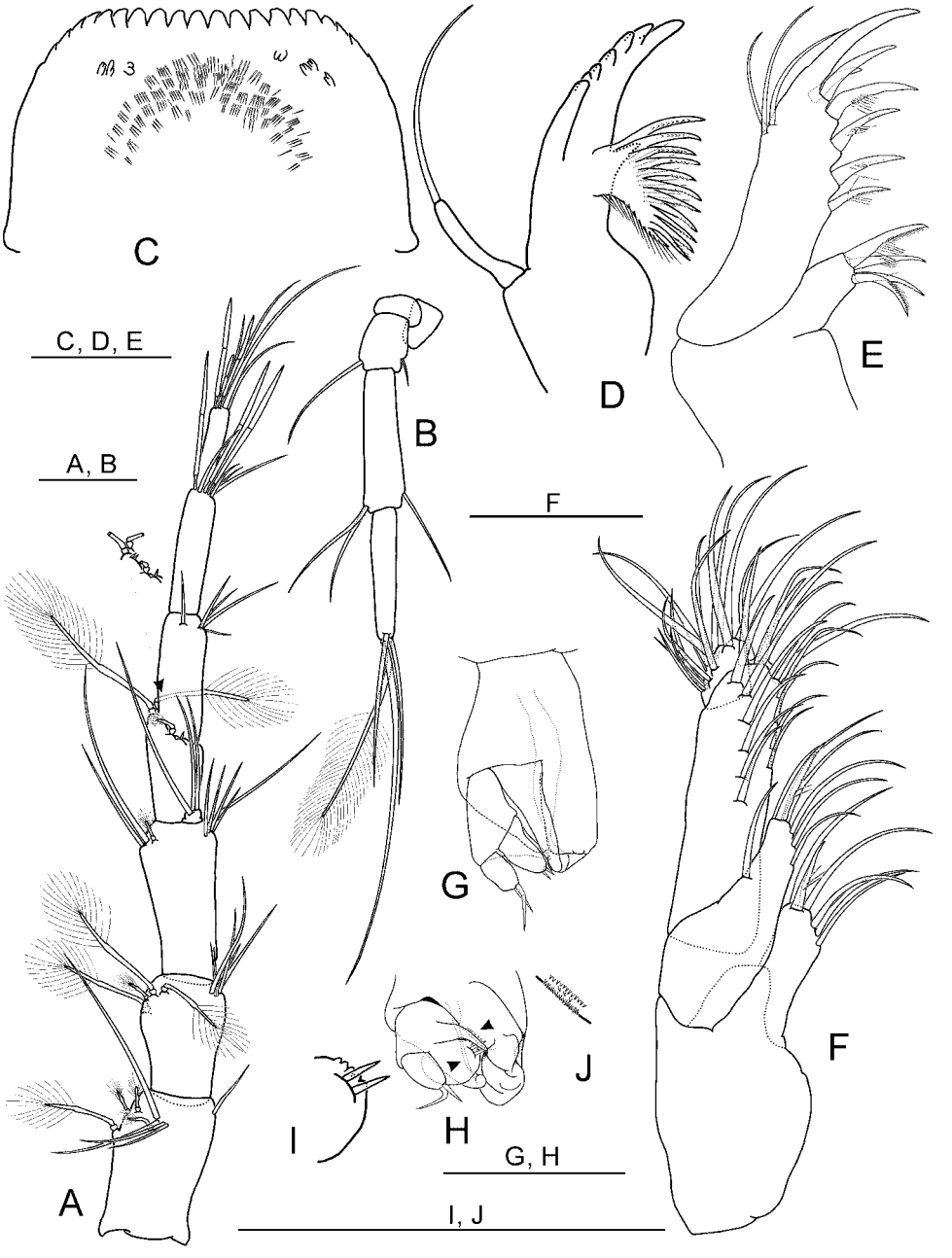

Figure 5. *Brevisomabathynella changjini* sp. nov. (♂, holotype): (A) right antennule (dorsal); (B) right antenna (dorsal); (C) labrum (ventral); (D) right mandible (ventral); (E) right maxillule I (ventral); (F) right maxilla II (dorsal); (G) right thoracopod VIII (lateral); (H) left thoracopod VIII (lateroventral); (I) exopod of left thoracopod VIII; (J) denticles of penial region of thoracopod VIII. Scale bars 0.1 mm.

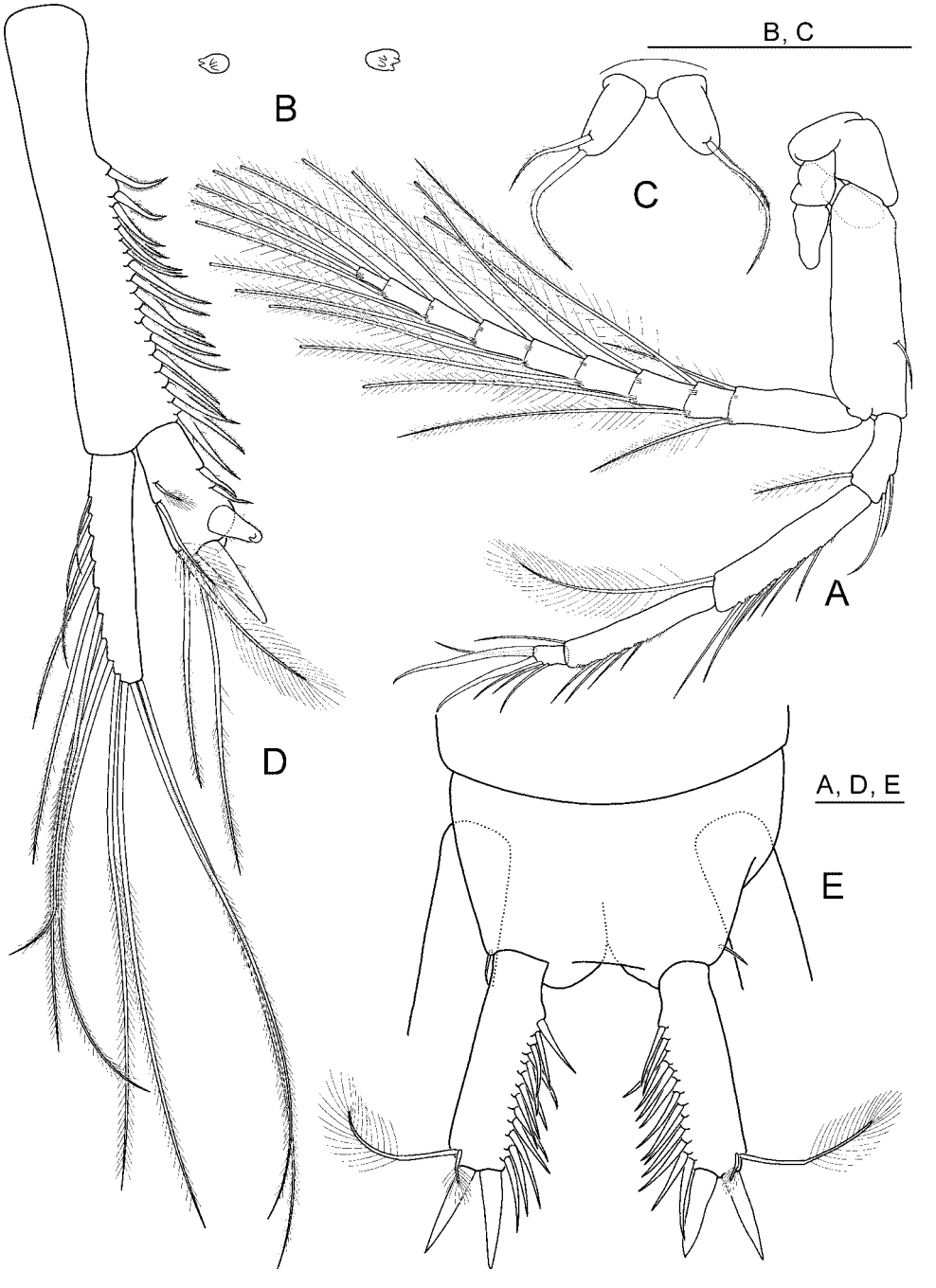

Figure 6. *Brevisomabathynella changjini* sp. nov. (♂, holotype; ♀, allotype): (A) right thoracopod VII ♂ (frontal); (B) right and left thoracopods VIII ♀ (ventral); (C) right and left pleopods I ♂ (ventral); (D) left uropod ♂ (dorsal); (E) pleotelson and furcal rami ♂ (dorsal). Scale bars 0.1 mm.

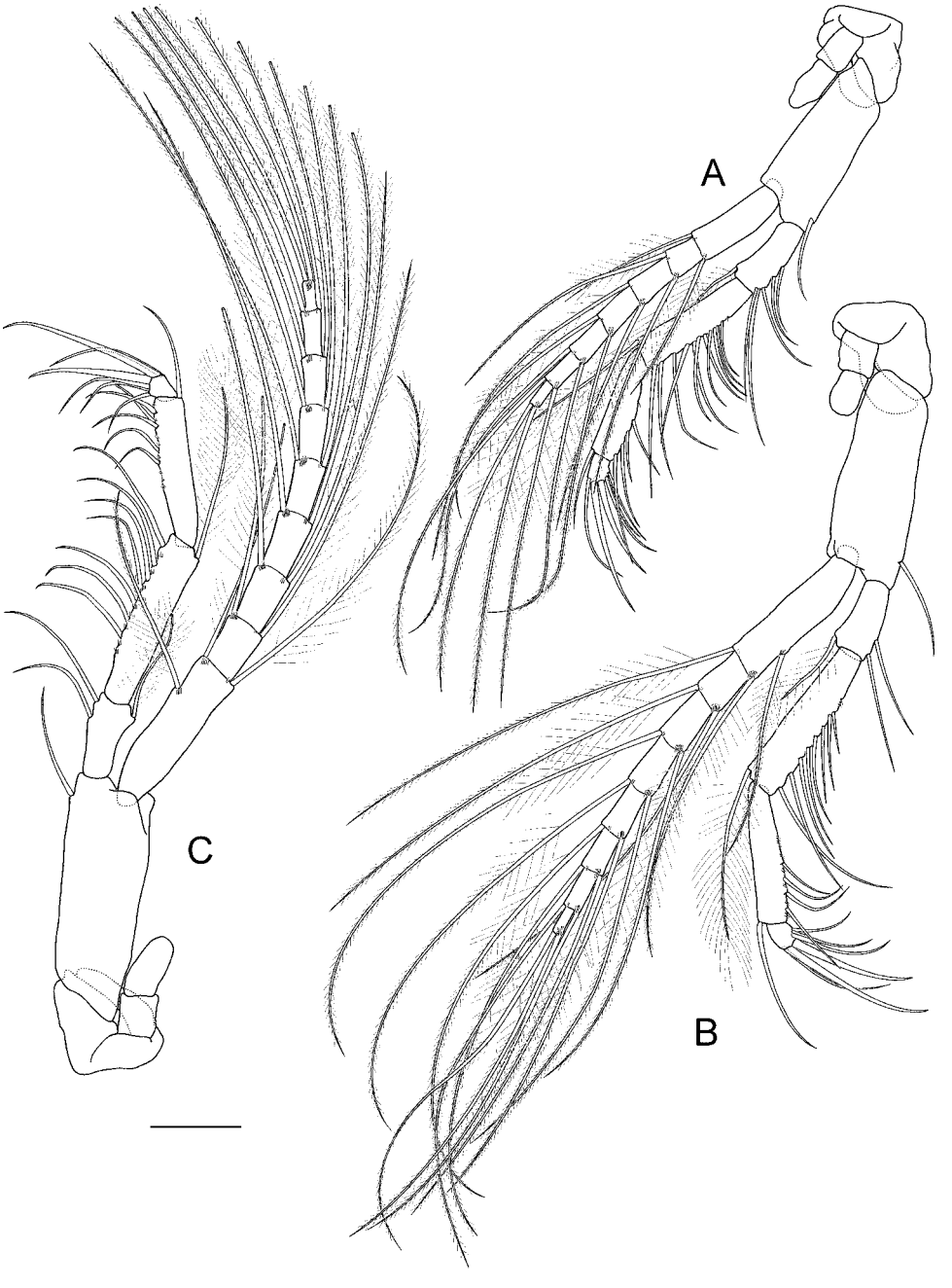

Figure 7. *Brevisomabathynella changjini* sp. nov. (♂, holotype): (A) right thoracopod I (frontal); (B) right thoracopod II (frontal); (C) right thoracopod III (frontal). Scale bar 0.1 mm.

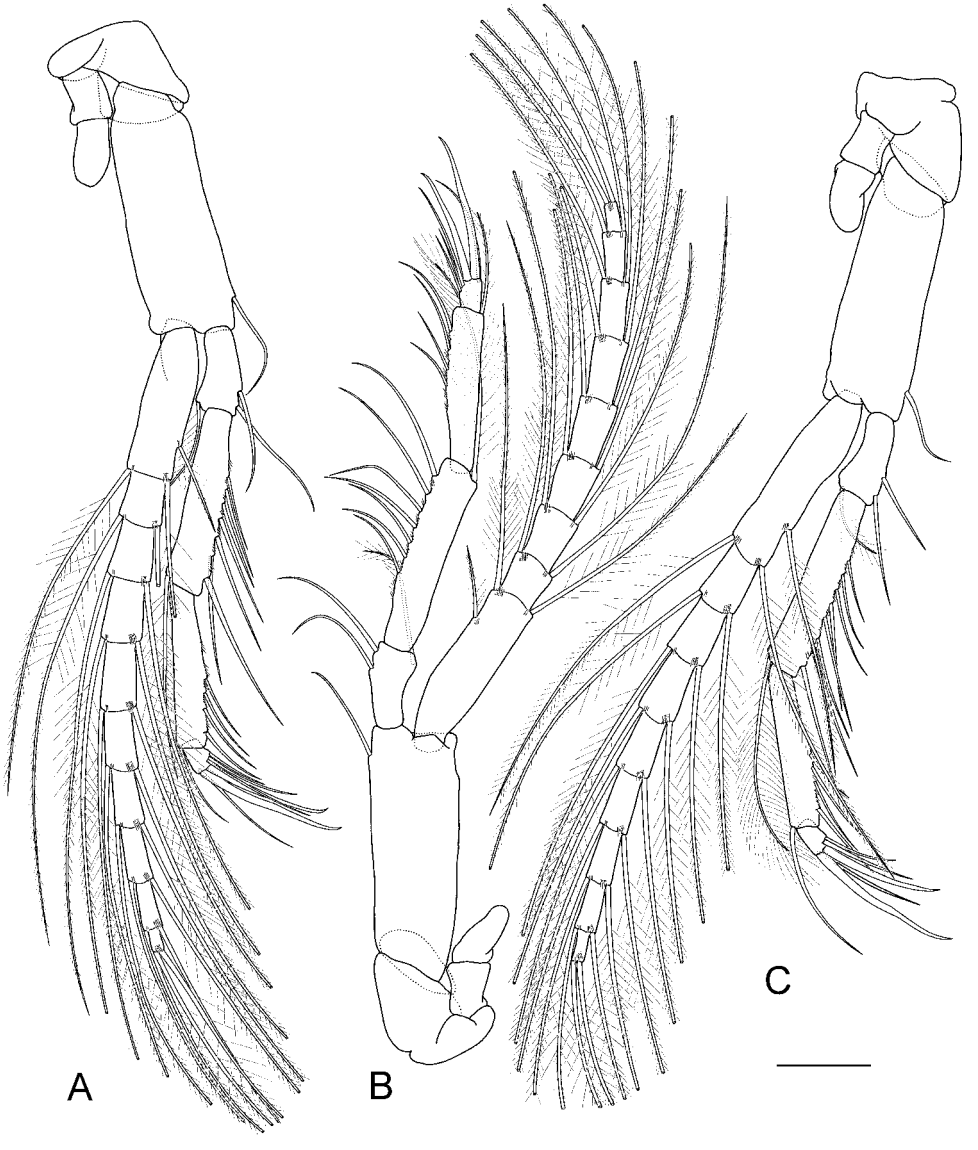

Figure 8. *Brevisomabathynella changjini* sp. nov. (♂, holotype): (A) right thoracopod IV (frontal); (B) right thoracopod V (frontal); (C) right thoracopod VI (frontal). Scale bar 0.1 mm.

Maxilla (Figure 5F). Four-segmented, setal formula 6-7-17-13.

Thoracopods I–VII (Figures 6A, 7A–C, 8A–C). Thoracopods I–IV increasing in size posteriorly. Thoracopods IV–VII similar in size. Thoracopods I–VII each bearing one epipod on protopod and one basipodal seta. Number of exopodal segments of thoracopods I–VII: 7-8-9-10-9,10-9-9. Endopod of thoracopods I–VII four-segmented, setal formulae:

Th. I	5+1/11+1/4+1/6(4)
Th. II	2+1/8+1/4+1/6(4)
Th. III	2+1/7+1/5+1/6(4)
Th. IV, V	2+1/7+1/4+1/6(4)
Th. VI	2+1/8+1/4+1/5(3)
Th. VII	2+1/6+1/4+1/6(4)

Thoracopod VIII (Figure 5G–J). More or less rectangular in lateral view, 1.3 times as long as wide. Protopod massive, with prominent penial region with terminal opening. Epipod large, triangular, distal part barely reaching penial region of protopod. Basipod without setae, inner margin of basipod drawn out into projection. Exopod one-third size of basipod, round, terminally with five denticles, bearing two subterminal setae (Figure 5I). Endopod two-thirds size of exopod, with two terminal setae.

First pleopod (Figure 6C). In form of two stubs attached to each other basally with a gap. Each stub bearing two terminal setae.

Uropod (Figure 6D). Eighteen spines of similar size on inner margin of sympod. Exopod 50% as long as sympod, without basiventral setae, and with 12 setae on outer and terminal margin. Endopod 30% as long as sympod, with two dorsal plumose setae near base, with two terminal setae and one subterminal plumose seta on outer margin, and with one terminal, one subterminal and two inner-marginal spines. Terminal and subterminal spines similar in size. Two inner-marginal spines spike-like, two-thirds of length of terminal spine, but thinner.

Pleotelson (Figure 6E). One seta near base of each furcal ramus on both sides. Anal operculum flat.

Furcal rami (Figure 6E). Four times as long as wide, with two large terminal spines, and 13 spines on inner margin, and with two dorsal setae.

Description of adult female (allotype)

Body. Length 4.12 mm. Identical to male except for following characters.

Antennule. Second segment with seven simple setae on inner margin. Third segment with six setae on inner margin.

Mandible. Spine row with 13 spines.

Thoracopods I–VII. Number of exopodal segments of thoracopods I–VII: 7-9-10-10-10-10-9. Setal formulae of endopods:

Th. I	4+1/8+1/4+1/5(3)
Th. II	2+1/7+1/4+1/6(4)
Th. III	2+1/6+1/4+1/6(4)
Th. IV	2+1/7+1/4+1/6(4)
Th. V, VI	2+1/6+1/4+1/6(4)
Th. VII	2+1/5+2/4+1/5(3)

Thoracopod VIII (Figure 6B). Conical, half as long as endopod of male thoracopod VIII, with four tiny teeth.

Uropod. Sympod with 15 spines.

Intraspecific variation

Range of body length: male 3.60–4.24 mm; female 3.60–4.12 mm. Variation in number of setae, spines or segments as listed in Table 2.

Etymology

The specific name refers to Prof. Jin Chang (Seoul, Korea), who encouraged J. L. Cho to study taxonomy.

Brevisomabathynella clayi **sp. nov.**

(Figures 9–12)

Material examined

Holotype (adult female), allotype (adult male), paratype (adult female). Holotype: dissected on six slides (WAM C 40312). Allotype: dissected on four slides (WAM C 40313). Paratype: as a whole specimen on a slide (WAM C 40314).

Type locality

Australia, Western Australia, Carey Palaeodrainage, Millbillillie Station, drainage between Lake Violet and Uramurdah calcretes, MEB site 266 (26°41′15″ S, 120°18′10″ E), BES 10524, 6 June 2004, leg. W.F. Humphreys, C.H.S. Watts and C. Clay.

Description of adult female (holotype)

Body. Length 3.52 mm. Head as long as anterior three thoracic segments 1–3 combined, approximately 11 times as long as wide (Figure 9A).

Antennule (Figure 9B). Seven-segmented. First segment with one seta on inner margin, with five simple dorsal setae and with one dorsal, one ventromedial and one lateral plumose seta. Second segment with one group of four plumose setae and with four simple setae on inner margin. Third segment with three lateral setae including one plumose seta and six setae on inner margin. Inner flagellum of third segment with three simple setae. Fourth segment with one stub seta and one plumose seta on dorsal margin, and with two stub setae and two plumose setae on outer distal apophysis. Fifth segment with three setae on inner margin and one dorsal seta. Sixth segment with four setae on inner margin and with dorsal group of two aesthetascs, one simple seta and one additional aesthetasc lateral to simple seta. Seventh segment with three subterminal aesthetascs and four simple setae.

Table 2. Intraspecific variation of *Brevisomabathynella changjini* sp. nov. (data acquired from the four dissected specimens).

	Holotype (♂)	Allotype (♀)	Paratype 1 (♂)	Paratype 2 (♀)
Body length (mm)	4.24	4.12	4.10	4.08
Antennule (segments)				
Second segment: no. setae on inner distal margin	6	7	6	6
Third segment: no. setae on inner distal margin	5	6	6	6
Fifth segment: no. of setae on inner distal margin	4	4	4	5
Thoracopods I–VII				
No. of exopodal segments	7-8-9-10-9,10-9-9	7-9-10-10-10-10-9	7-8-9-9-10-9-8	7-9-10-10-10-10-9
Setal formula of Th. I	5+1/11+1/4+1/6(4)	4+1/8+1/4+1/5(3)	4+1/8+1/4+1/6(4)	4+1/9+1/4+1/5(3)
Setal formula of Th. II	2+1/8+1/4+1/6(4)	2+1/7+1/4+1/6(4)	2+1/7+1/4+1/6(4)	2+1/8+1/4+1/6(4)
Setal formula of Th. III	2+1/7+1/5+1/6(4)	2+1/6+1/4+1/6(4)	2+1/8+1/4+1/6(4)	2+1/8+1/4+1/5(3)
Setal formula of Th. IV	2+1/7+1/4+1/6(4)	2+1/7+1/4+1/6(4)	2+1/7+1/4+1/6(4)	2+1/8+1/4+1/5(3)
Setal formula of Th. V	2+1/7+1/4+1/6(4)	2+1/6+1/4+1/6(4)	2+1/7+1/4+1/6(4)	2+1/7+1/4+1/5(3)
Setal formula of Th. VI	2+1/8+1/4+1/5(3)	2+1/6+1/4+1/6(4)	2+1/7+1/4+1/6(4)	1+1/7+1/4+1/5(3)
Setal formula of Th. VII	2+1/6+1/4+1/6(4)	2+1/5+2/4+1/5(3)	2+1/7+1/4+1/5(3)	1+1/6+1/3+1/5(3)
Uropod				
No. of spines on sympod	18	15	15	19
No. of setae on exopod	12	15	15	12
Furcal rami				
No. of spines on inner margin	13	13	13	12

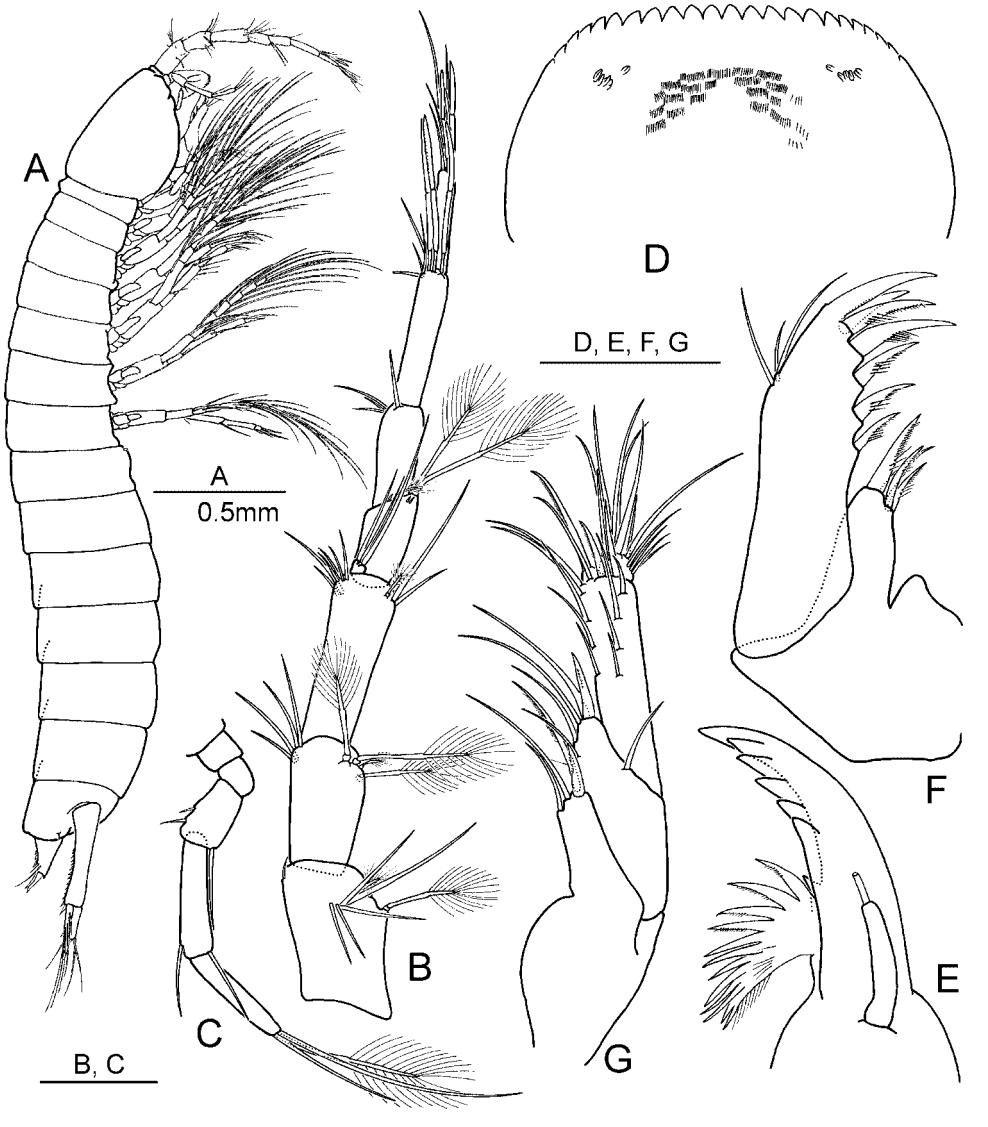

Figure 9. *Brevisomabathynella clayi* sp. nov. (♀, holotype): (A) general habitus; (B) right antennule (dorsal); (C) right antenna (dorsal); (D) labrum (ventral); (E) right mandible (dorsal); (F) right maxillule (ventral); (G) right maxilla (dorsal). Scale bars 0.1 mm (unless otherwise specified).

Antenna (Figure 9C). Five-segmented, as long as antennular segments 1–3 combined. Fourth segment as long as fifth segment. Setal formula: 0+0/0+0/1+2/1+1/3(1). Plumose seta of distal segment shorter than longest simple seta.

Labrum (Figure 9D). Flat with 10 median teeth of more or less similar size flanked by six (right) or seven (left) smaller teeth on each side. Ventral surface with numerous combs of ctenidia and 10 teats.

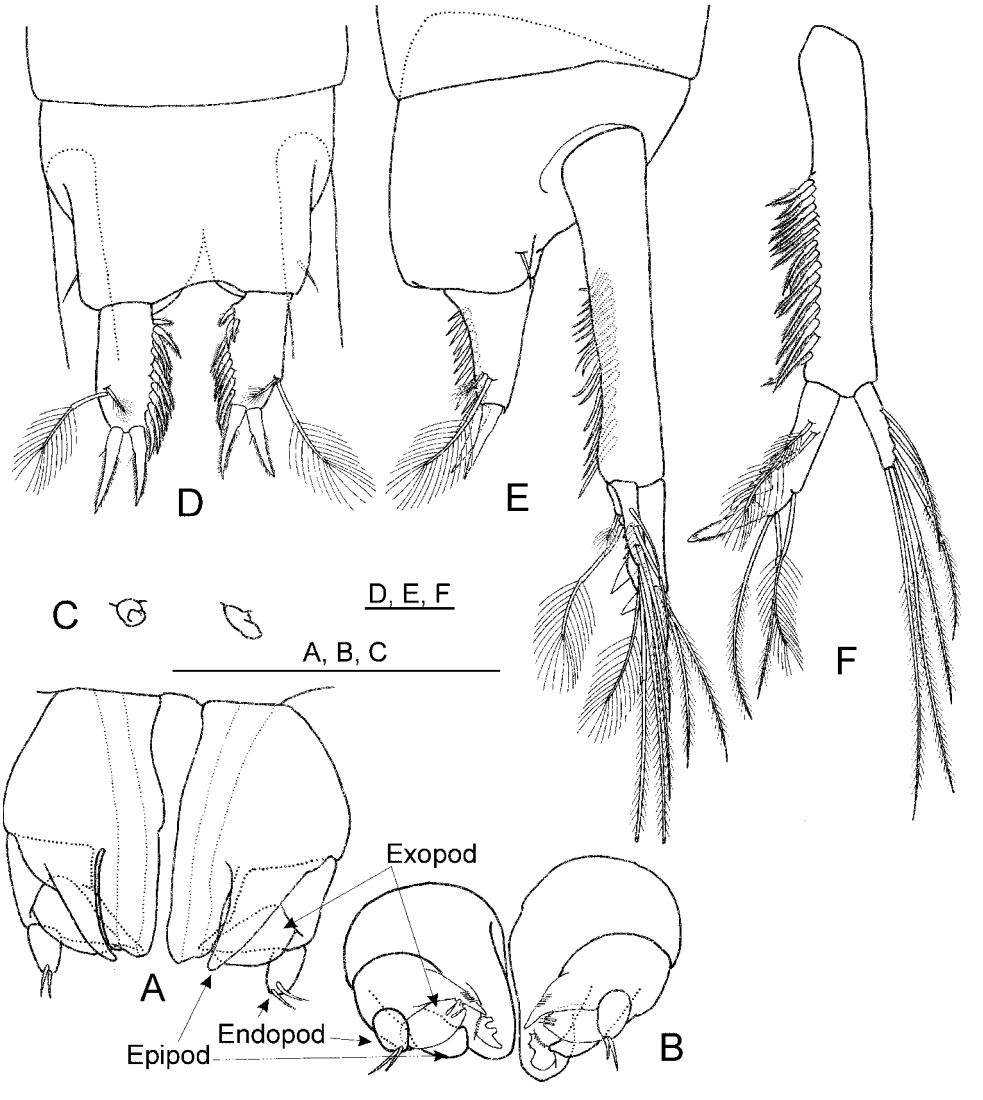

Figure 10. *Brevisomabathynella clayi* sp. nov. (♀, holotype; ♂, allotype): (A) right and left thoracopods VIII ♂ (frontal); (B) right and left thoracopods VIII ♂ (ventral); (C) right and left thoracopods VIII ♀ (ventral); (D) pleotelson and furcal rami ♀ (dorsal); (E) pleotelson, furcal rami and uropod ♀ (lateral); (F) right uropod ♀ (dorsal). Scale bars 0.1 mm.

Mandible (Figure 9E). Incisor process of six teeth. Tooth of ventral edge triangular. Spine row consisting of 12 spines. Palp of one segment, with one seta.

Maxillule (Figure 9F). Two-segmented. Proximal segment with four setae on inner margin. Distal segment with two terminal spines, with five spines with denticles on inner edge, and with three simple setae on outer margin.

Maxilla (Figure 9G). Four-segmented, setal formula 4-6-14-11.

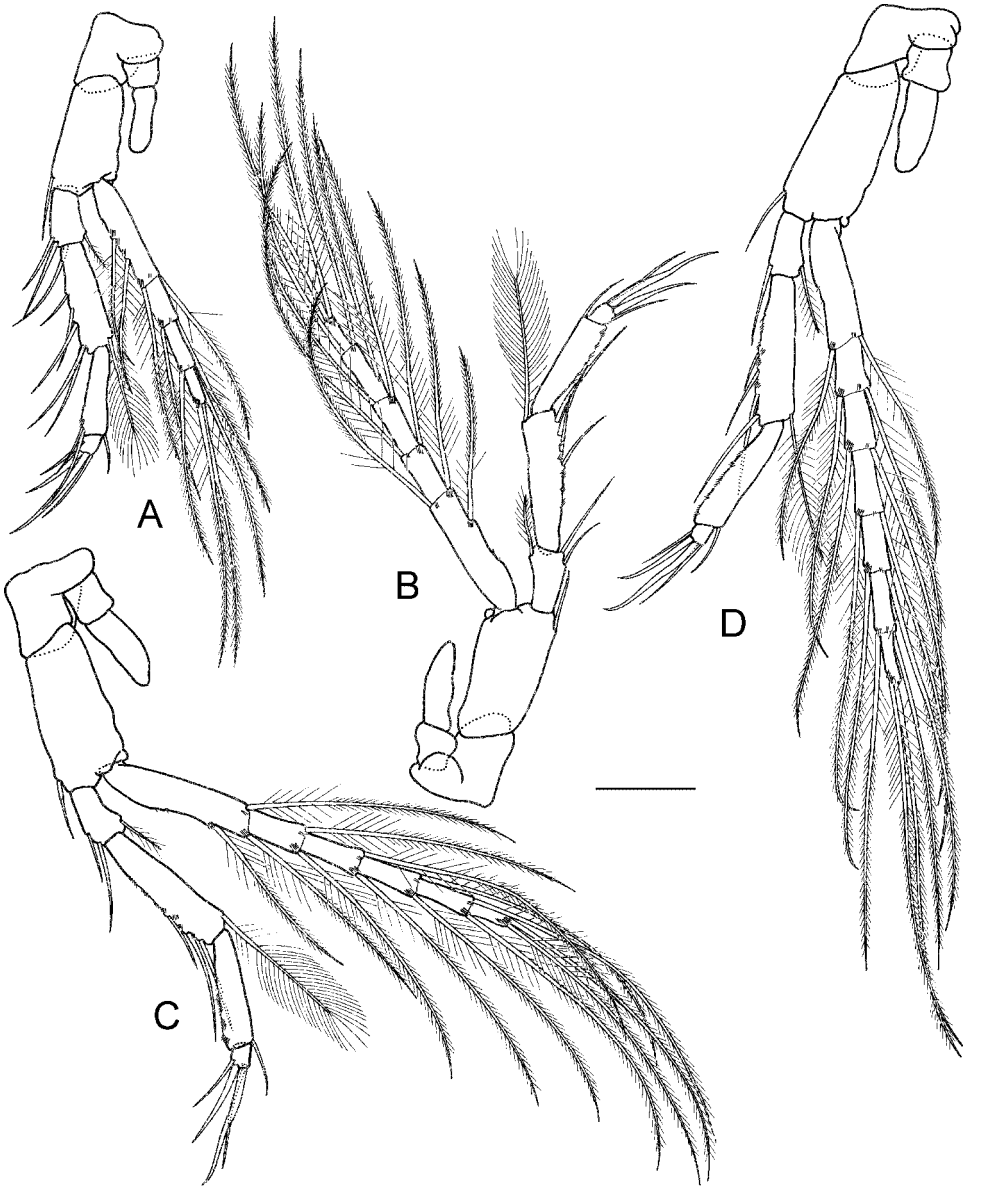

Figure 11. *Brevisomabathynella clayi* sp. nov. (♀, holotype): (A) left thoracopod I (frontal); (B) left thoracopod II (frontal); (C) left thoracopod III (frontal); (D) left thoracopod IV (frontal). Scale bar 0.1 mm.

Thoracopods I–VII (Figures 11A–D, 12A–C). Thoracopods I–IV increasing in size posteriorly. Thoracopods IV–VII similar in size. Thoracopods I–VII each bearing one epipod on protopod. Basipod of thoracopods I–VII with one seta. Number of exopodal segments of thoracopods I–VII: 4-5-6-7-7-7-7. Endopod of thoracopods I–VII four-segmented, setal formulae:

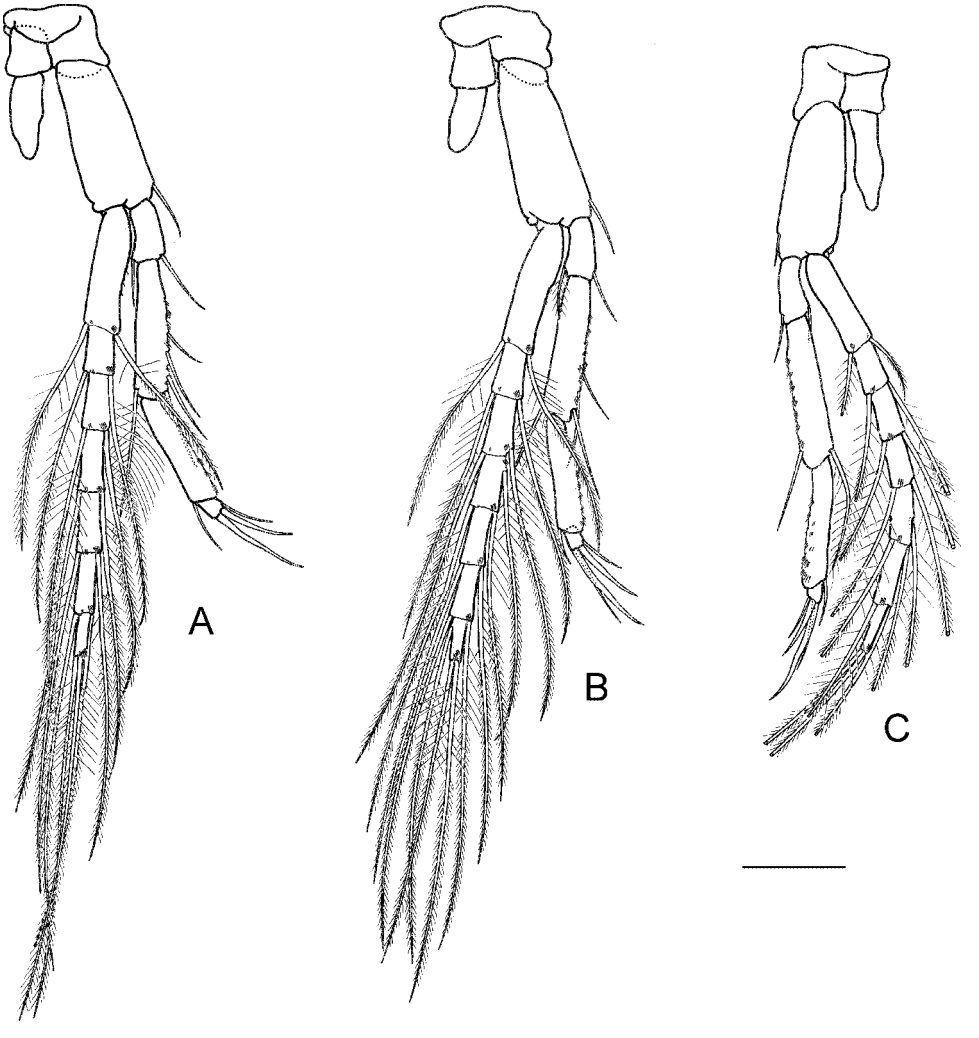

Figure 12. *Brevisomabathynella clayi* sp. nov. (♀, holotype): (A) left thoracopod V (frontal); (B) left thoracopod VI (frontal); (C) right thoracopod VII (frontal). Scale bar 0.1 mm.

Th. I	3+1/5+1/2+1/4(2)
Th. II	2+1/4+1/0+1/4(2)
Th. III	2+1/3+1/0+1/4(2)
Th. IV, V	1+1/4+1/0+1/4(2)
Th. VI	1+1/3+1/0+1/4(2)
Th. VII	1+1/1+1/0+1/4(2)

Thoracopod VIII (Figure 10C). Conical, half as long as endopod of male thoracopod VIII.

First pleopod. Absent.

Uropod (Figure 10E,F). Sixteen spines of similar size on inner margin of sympod. Exopod 23% as long as sympod, with six setae on outer and terminal margin, without basiventral setae. Endopod 38% as long as sympod, with two dorsal plumose setae near base, with two terminal setae and one subterminal plumose seta on outer margin and with one terminal, one subterminal and three additional spines on inner margin. Terminal spine thicker and 1.5 times as long as subterminal spine. Three inner-marginal spines spike-like, two-thirds as long as subterminal spine.

Pleotelson (Figure 10D,E). One seta near base of each furcal ramus on both sides. Anal operculum concave.

Furcal rami (Figure 10D,E). 1.5 times as long as wide, with two large terminal spines, 11 (left) or 10 (right) additional spines on inner margin, and with two dorsal setae.

Description of adult male (allotype)

Body. Length 2.36 mm. Identical to female except for following characters.

Antennule. First segment with four simple dorsal setae. Third segment with five setae on inner margin.

Mandible. Spine row with 10 spines.

Thoracopods I–VII. Number of exopodal segments of thoracopods I–VII: 3-4-5-5-5-5-4. Setal formulae of endopods:

Th. I	3+1/4+1/1+1/4(2)
Th. II–V	1+1/3+1/0+1/4(2)
Th. VI	1+1/2+1/0+1/4(2)
Th. VII	1+1/1+1/0+1/4(2)

Thoracopod VIII (Figure 10A,B). Rectangular in frontal view, twice as long as wide. Protopod massive, with prominent penial region with terminal opening. Epipod large, triangular, distal part barely reaching penial region of protopod. Basipod without setae, inner margin of basipod drawn out into projection, of which outer margin is equipped with fine hairs. Exopod one-third size of basipod, triangular, terminally with five denticles, bearing two subterminal setae. Endopod half as long as exopod, with two terminal setae.

Uropod. Sympod with 12 spines. Exopod with five setae.

Furcal rami. Both right and left furcal rami with eight spines on inner margin.

Intraspecific variation

Body length of paratype: 3.30 mm. Paratype does not differ from holotype.

Etymology

The specific name refers to one of the collectors (C. Clay: Adelaide, Australia).

Brevisomabathynella uramurdahensis sp. nov.
(Figures 13–18)

Material examined

Holotype (adult male), allotype (adult female), paratypes (two adult males and one adult female). Holotype dissected on seven slides (WAM C 40079). Allotype dissected on seven slides (WAM C 40080). Paratypes: one adult male and one adult female each dissected on six slides, one adult male as a whole specimen on a slide (WAM C 40081–C 40083).

Type locality

Australia, Western Australia, Carey Palaeodrainage, Millbillillie Station, Uramurdah Lake, MEB site 264 (26°41′15″ S, 120°20′18″ E), BES 10515, 3 June 2004, leg. W.F. Humphreys, C.H.S. Watts and C. Clay.

Other locality

One adult male and one adult female each dissected on five slides, two adult males and two adult females each as a whole specimen on separate slides, MEB site 262 (26°41′15″ S, 120°21′11″ E), BES 6449, 5 September 2004, leg. W.F. Humphreys and C.H.S. Watts, (WAM C 40084).

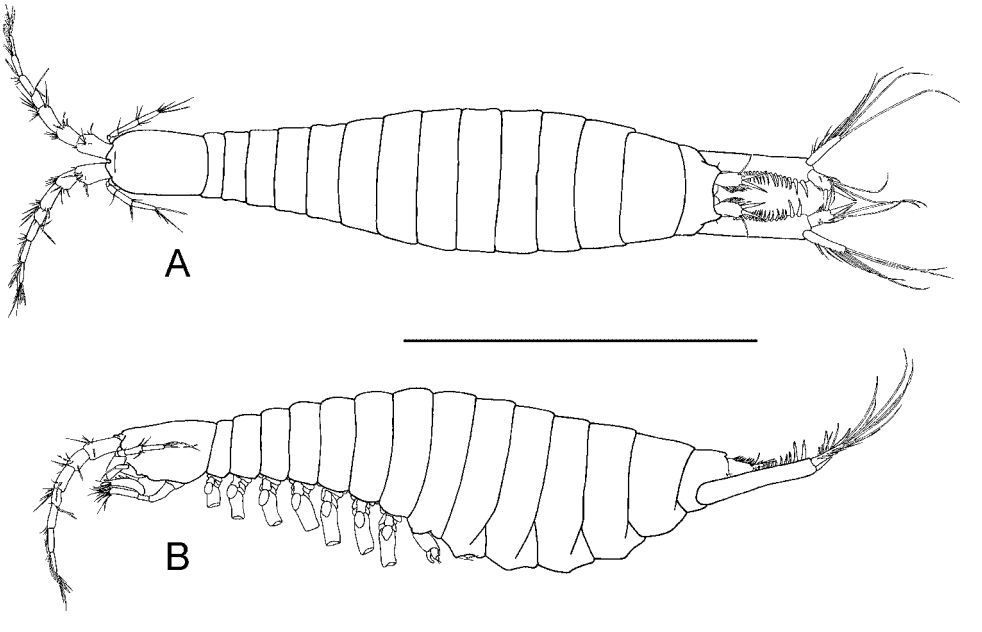

Figure 13. General habitus of *Brevisomabathynella uramurdahensis* sp. nov. (♂, paratype): (A) dorsal; (B) lateral. Scale bar 2 mm.

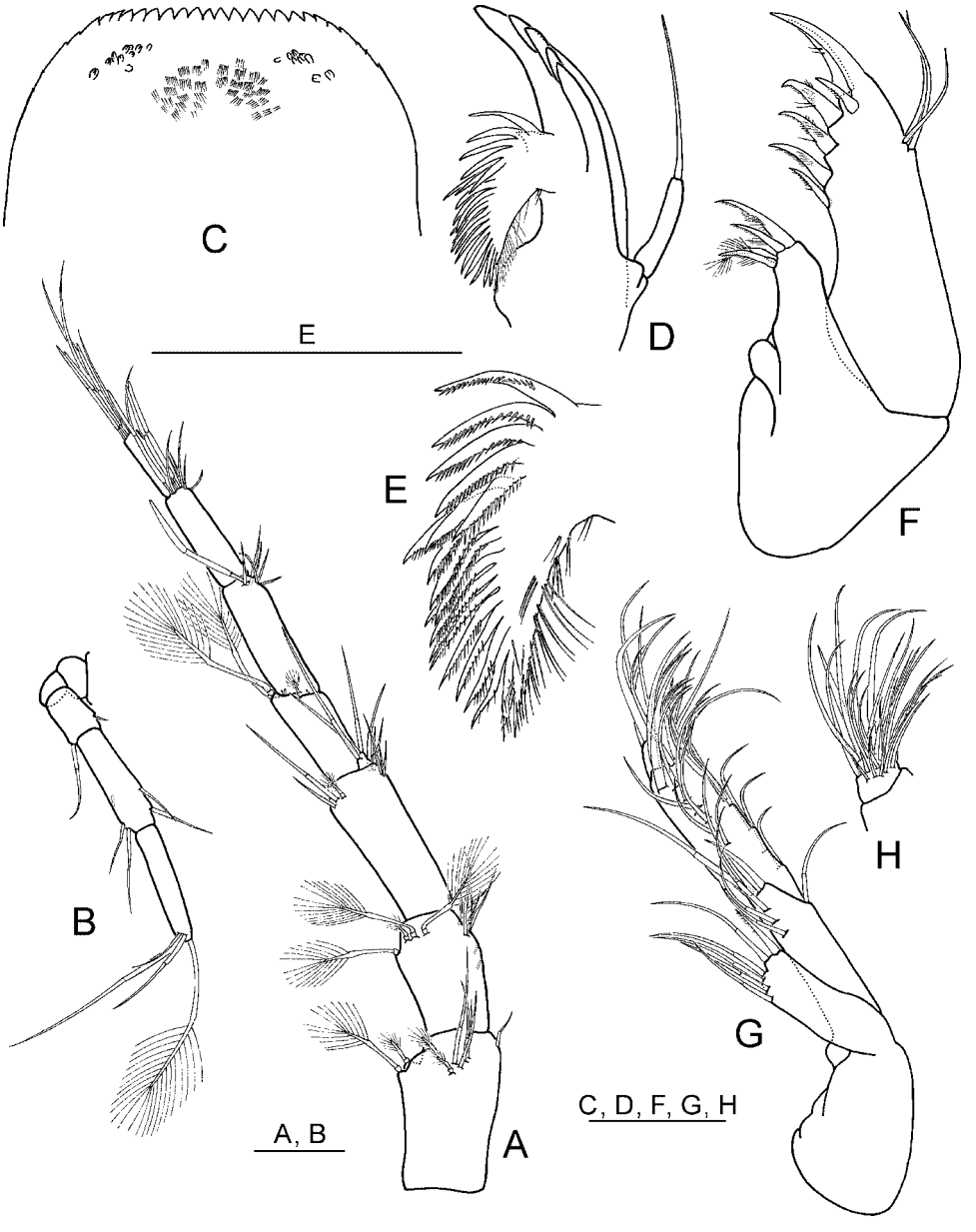

Figure 14. *Brevisomabathynella uramurdahensis* sp. nov. (♂, holotype): (A) left antennules (dorsal); (B) left antenna (dorsal); (C) labrum (ventral); (D) right mandible (dorsal); (E) spine row of right mandible (dorsal); (F) right maxillule (dorsal); (G) right maxilla (inner lateral); (H) fourth segment of right maxilla (outer lateral). Scale bars 0.1 mm.

Description of adult male (holotype)

Body. Length 3.62 mm, fat-bellied, width of body at first segment 0.31 mm, increasing posteriorly to 0.70 mm at 10th segment and then decreasing (Figure 13A,B). Head as long as anterior three thoracic segments 1–3 combined.

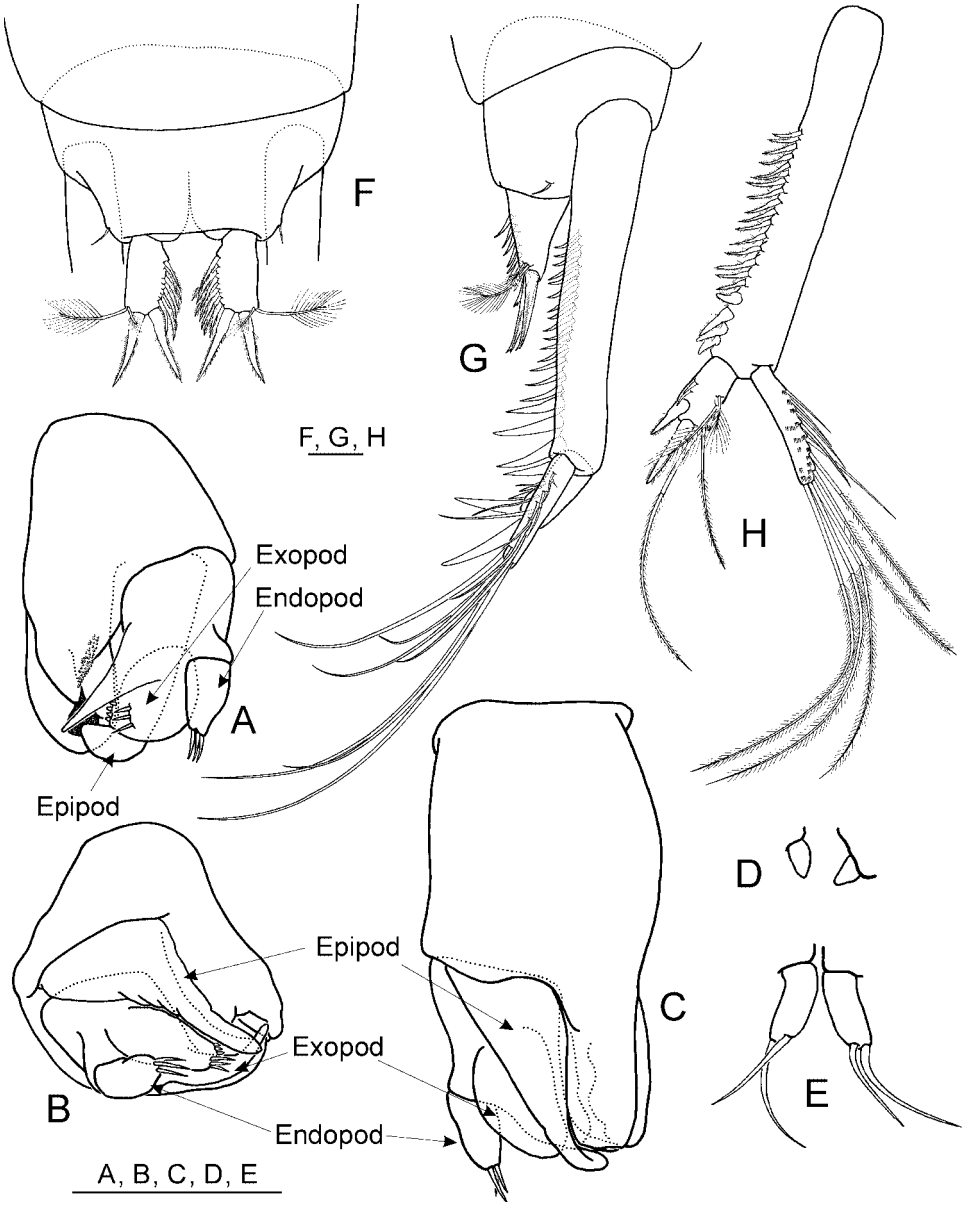

Figure 15. *Brevisomabathynella uramurdahensis* sp. nov. (♂, holotype; ♀, allotype): (A) right thoracopod VIII ♂ (inner lateral); (B) right thoracopod VIII ♂ (ventral); (C) right thoracopod VIII ♂ (frontal); (D) right and left thoracopods VIII ♀ (ventral); (E) right and left pleopods I ♂; (F) pleotelson and furcal rami (dorsal); (G) pleotelson, furcal rami and uropod (lateral); (H) right uropod ♂. Scale bars 0.1 mm.

Antennule (Figure 14A). Seven-segmented. First segment with one seta on inner margin, with four simple dorsal setae and with one dorsal, one ventromedial and two lateral plumose setae. Second segment with one group of four plumose setae and with six simple setae on inner margin. Two openings on inner margin. Third segment with three lateral

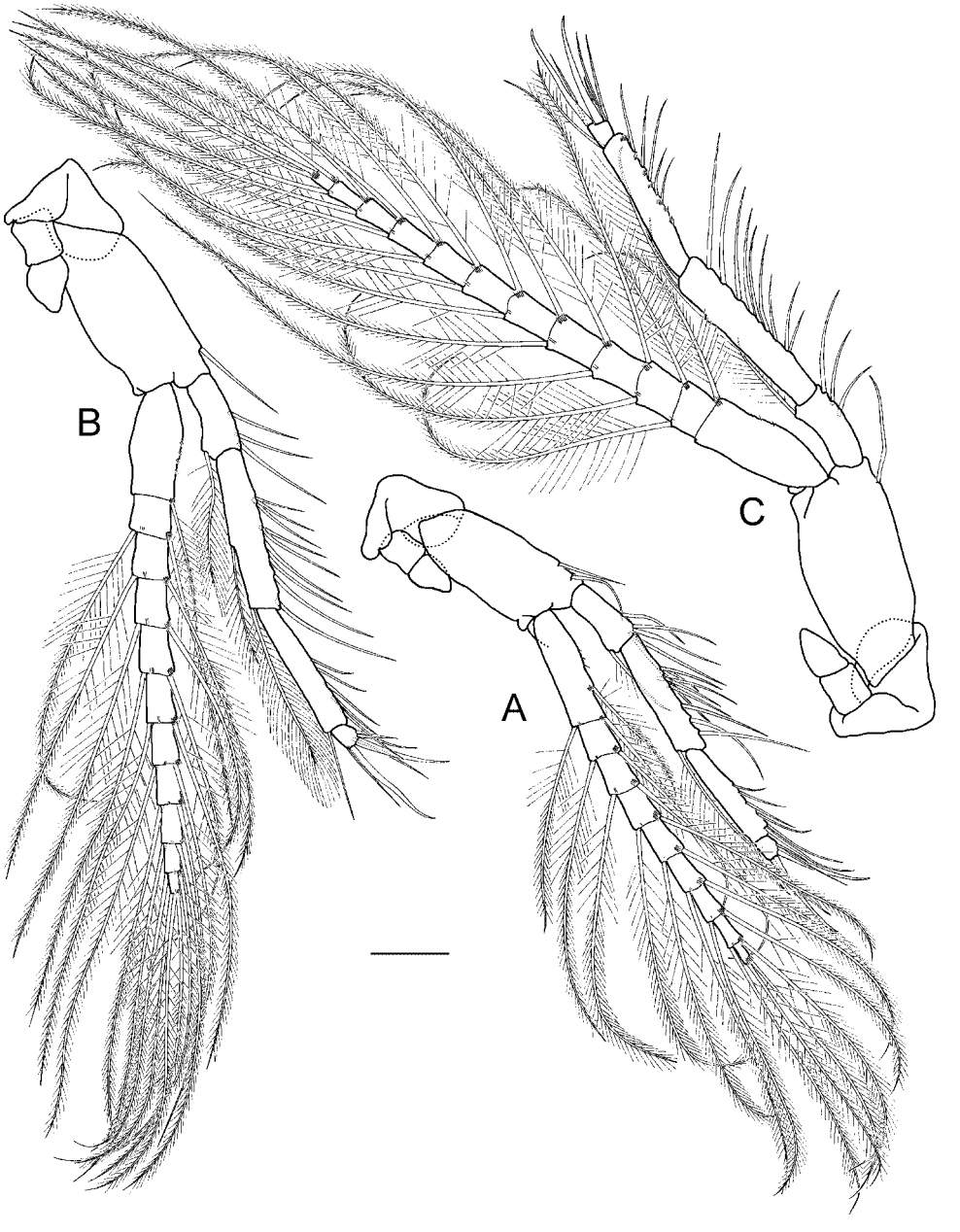

Figure 16. *Brevisomabathynella uramurdahensis* sp. nov. (♂, holotype): (A) right thoracopod I (frontal); (B) right thoracopod II (frontal); (C) left thoracopod III (frontal). Scale bar 0.1 mm.

setae including one plumose seta and six setae on inner margin. Inner flagellum of third segment with three simple setae. Fourth segment with one stub seta and one plumose seta on dorsal margin, and with two stub setae and two plumose setae on outer distal apophysis. Fifth segment with five setae on inner margin, and with one simple seta and one

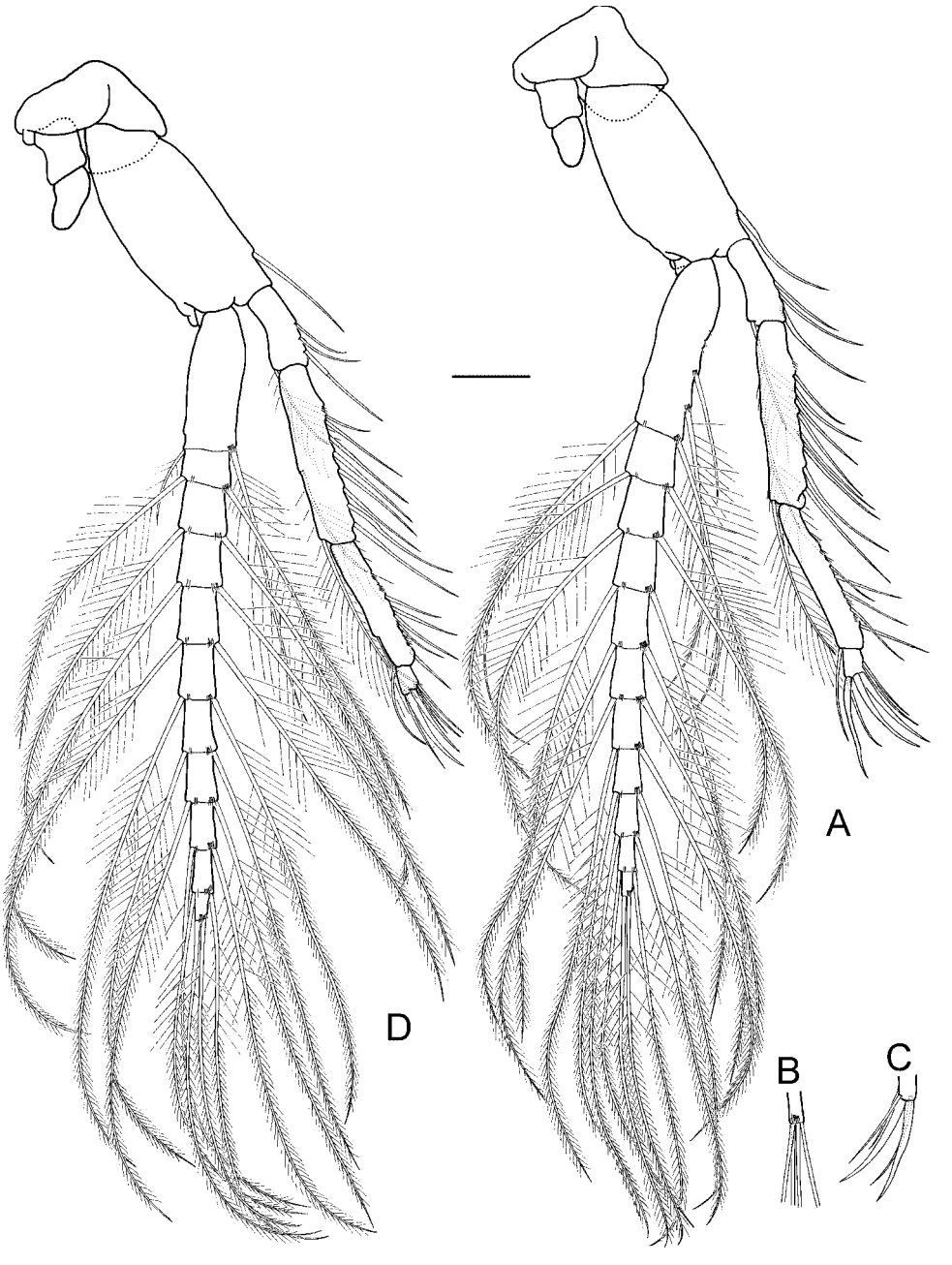

Figure 17. *Brevisomabathynella uramurdahensis* sp. nov. (♂, holotype): (A) right thoracopod IV (frontal); (B) distal segment of exopod of left thoracopod IV (frontal); (C) distal segment of endopod of left thoracopod IV (frontal); (D) right thoracopod V (frontal). Scale bar 0.1 mm.

aesthetasc dorsally. Sixth segment with four setae on inner margin and with dorsal group of two aesthetascs, one simple seta and one additional aesthetasc lateral to simple seta. Seventh segment with three subterminal aesthetascs and four simple setae.

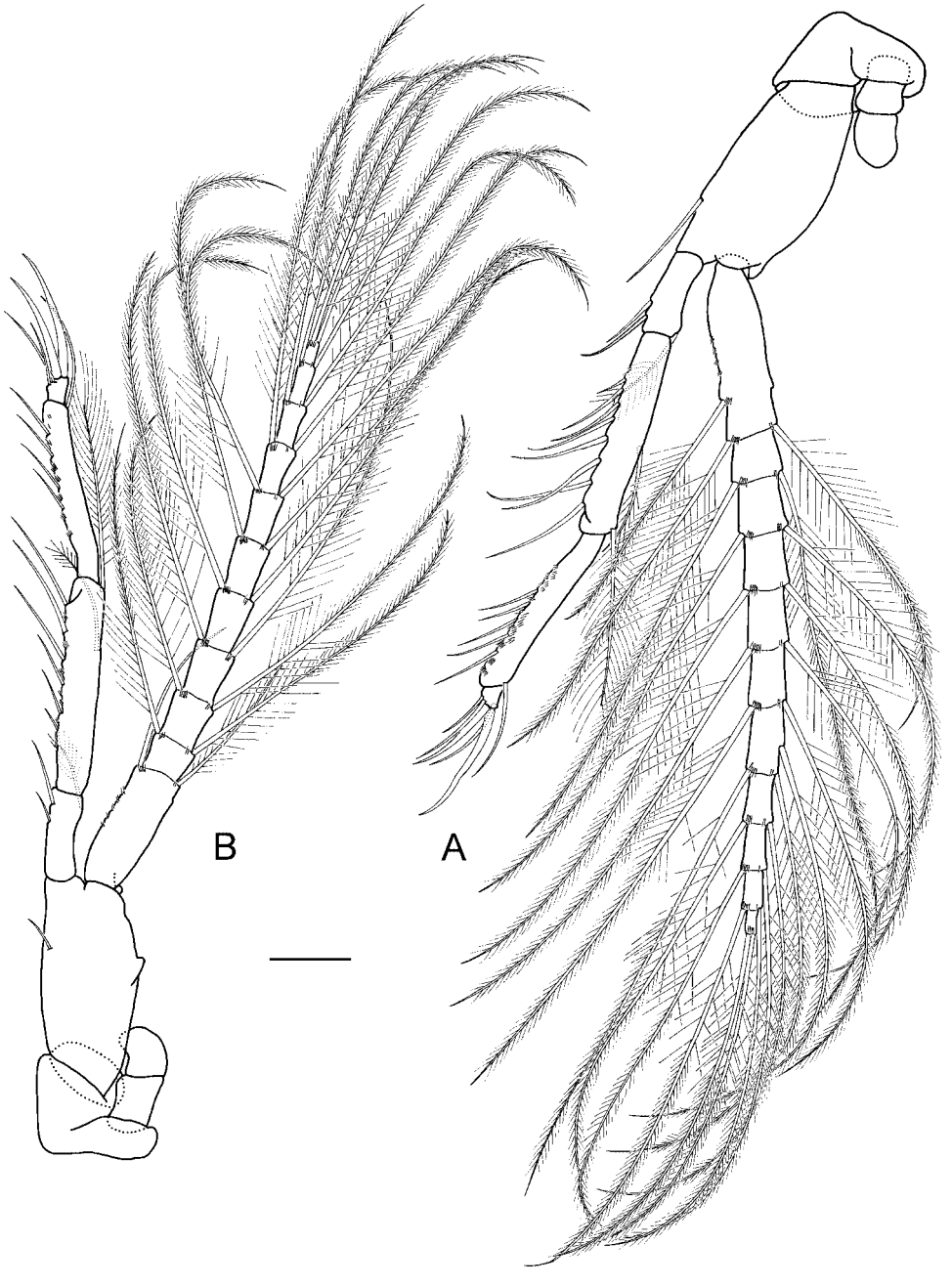

Figure 18. *Brevisomabathynella uramurdahensis* sp. nov. (♂, holotype): (A) left thoracopod VI (frontal); (B) right thoracopod VII (frontal). Scale bar 0.1 mm.

Antenna (Figure 14B). Five-segmented, as long as antennular segments 1–3 combined. Fourth segment as long as fifth segment. Setal formula: 0+0/0+0/1+1/2+2/4(1). Plumose seta of distal segment shorter than longest simple seta.

Labrum (Figure 14C). Flat with 14 median teeth of more or less similar size flanked by six (left) or seven (right) teeth decreasing in size laterally on each sides. Ventral surface with numerous combs of ctenidia and teats.

Mandible (Figure 14D,E). Incisor process of five teeth. Tooth of ventral edge triangular. Spine row consisting of 20 spines. Palp of one segment, with one apical seta.

Maxillule (Figure 14F). Two-segmented. Proximal segment with four setae on inner margin. Distal segment with two terminal spines, with five spines with denticles on inner edge, and with three simple setae on outer margin.

Maxilla (Figure 14G,H). Four-segmented, setal formula 6-7-22-24.

Thoracopods I–VII (Figures 16A–C, 17A–D, 18A,B). Thoracopods I–IV increasing in size posteriorly. Thoracopods IV–VII similar in size. Thoracopods I–VII each bearing one epipod on protopod. Basipod of thoracopod I with two setae, while that of thoracopods II–VII with one seta. Number of exopodal segments of thoracopods I–VII: 9-11-12-11-11-11-11. Endopod of thoracopods I–VII four-segmented, setal formulae:

Th. I	5+1/8+1/6+1/4(2)
Th. II, III	3+1/9+2/5+1/6(4)
Th. IV	3+1/8+2/5+1/6(4), 5(3)
Th. V	3+1/8+2/5+2/6(4)
Th. VI	2+1/8+2/5+1/5(3)
Th. VII	2+1/6+2/4+1/4(2)

Thoracopod VIII (Figure 15A–C). More or less rectangular in frontal view, twice as long as wide. Protopod massive, with prominent penial region with terminal opening. Epipod large, triangular, distal part covering penial region of protopod. Basipod without setae, inner margin of basipod drawn out into sharp projection. Exopod one third size of basipod, triangular, bearing five terminal teeth and three subterminal setae. Endopod as long as exopod, with three terminal setae.

First pleopod (Figure 15E). In form of two stubs attached to each other basally. Each stub bearing two terminal setae.

Uropod (Figure 15G,H). Twenty spines on inner margin of sympod. Four distal spines significantly thicker than others. Exopod 32 % as long as sympod, with ten setae on outer and terminal margin, without basiventral setae. Endopod 19% as long as sympod, with two dorsal plumose setae near base, with two terminal setae and one subterminal plumose seta on outer margin, and with one terminal, one subterminal and two inner-marginal spines. Terminal spine somewhat longer than subterminal spine. Two inner-marginal spines spike-like, half as long as terminal spine and thin.

Pleotelson (Figure 15F,G). One seta near base of each furcal ramus on both sides. Anal operculum flat.

Furcal rami (Figure 15F,G). Twice as long as wide, with two large terminal spines, and nine (right) or ten (left) spines on inner margin, and with two dorsal setae.

Description of adult female (allotype)

Body. Length 3.60 mm. Identical to male except for following characters:

Antennule. Second segment with eight simple setae on inner margin. Third segment with five setae on inner margin. Fifth segment with five setae on inner margin.

Antenna. Setal formula: 0+0/0+0/1+1/2+2/5(1).

Thoracopods I – VII. Number of exopodal segments of thoracopods I – VII: 8-9-10-11-11-10-10. Setal formulae of endopods:

Th. I	4+1/8+1/4+1/5(3)
Th. II	3+1/7+2/4+1/5(3)
Th. III	3+1/8+2/4+1/5(3)
Th. IV, V	3+1/7+2/5+1/5(3)
Th. VI	2+1/7+2/5+1/5(3)
Th. VII	2+1/5+2/4+1/5(3)

Thoracopod VIII (Figure 15D). Conical, half as long as endopod of male thoracopod VIII.

Uropod. Sympod with 18 spines. Exopod with 11 setae.

Intraspecific variation

Range of body length: male 3.30–3.62 mm; female 3.20–3.60 mm. Variation in number of setae, spines or segments as listed in Table 3.

Etymology

The specific name refers to Lake Uramurdah.

***Brevisomabathynella jundeeensis* sp. nov.**

(Figures 19–22)

Material examined

Holotype (adult male), allotype (adult female), paratypes (five adult males and five adult females). Holotype dissected on five slides (WAM C 40085). Allotype dissected on six slides, same data as for holotype, except BES 6471 (26°21′22″ S, 120°38′56″ E) (WAM C 40086). Paratypes: two adult males and one adult female each dissected on five slides, same data as for allotype (WAM C 40281, C 40888, C 40889).

Table 3. Intraspecific variation of *Brevisomabathynella uramurdahensis* sp. nov. (data acquired from the four dissected specimens).

	Holotype (♂)	Allotype (♀)	Paratype 1 (♂)	Paratype 2 (♂)	Paratype 3 (♀)	Paratype 4 (♀)
Body length (mm)	3.62	3.60	3.45	3.11	3.51	3.49
Antennule (segments)						
First segment: no. dorsal setae	4	4	3	4	4	3
Second segment: no. setae on inner distal margin	6	8	5	5	8	7
Third segment: no. setae on inner distal margin	6	5	5	5	6	5
Fifth segment: no. of setae on inner distal margin	5	5	4	4	5	4
No. of setae on fourth antennal segment	2+2	2+2	2+2	2+1	2+2	2+2
No. of spines of spine row of mandible	20	20	14	14	20	14
Setal formula of maxilla	6-7-22-24	6-7-22-24	5-6-22-20	4-6-20-18	6-7-20-22	5-6-20-18

(*Continued*)

Table 3. (Continued).

	Holotype (♂)	Allotype (♀)	Paratype 1 (♂)	Paratype 2 (♂)	Paratype 3 (♀)	Paratype 4 (♀)
Thoracopods I–VII						
No. of exopodal segments	9-11-12-11-11-11-11	8-9-10-11-11-10-10	8-9-10-11-10-10-90	7-8-9-9-9-9-8	9-10-11-12-11-11-10	8-10-10-10-10-10-0
Setal formula of Th. I	5+1/8+1/6+1/4(2)	4+1/8+1/4+1/5(3)	4+1/7+1/4+1/5(3)	4+1/7+1/3+1/5(3)	5+1/9+2/5+1/5(3)	5+1/6+2/4+1/5(3)
Setal formula of Th. II	3+1/9+2/5+1/6(4)	3+1/7+2/4+1/5(3)	3+1/7+2/4+1/5(3)	3+1/6+2/3+1/5(3)	4+1/8+2/5+1/5(3)	4+1/7+2/5+1/5(3)
Setal formula of Th. III	3+1/9+2/5+1/6(4)	3+1/8+2/4+1/5(3)	3+1/7+2/4+1/6(4)	3+1/6+2/3+1/5(3)	3+1/9+2/5+1/6(4)	4+1/8+2/4+1/6(4)
Setal formula of Th. IV	3+1/8+2/5+1/6(4),5(3)	3+1/7+2/5+1/5(3)	3+1/7+2/4+1/6(4)	3+1/6+2/3+1/5(3)	3+1/8+2/5+1/6(4)	3+1/7+2/5+1/6(4)
Setal formula of Th. V	3+1/8+2/5+2/6(4)	3+1/7+2/5+1/5(3)	3+1/7+2/3+1/5(3)	3+1/6+2/3+1/5(3)	3+1/9+2/5+1/5(3)	3+1/7+2/4+1/5(3)
Setal formula of Th. VI	2+1/8+2/5+1/5(3)	2+1/7+2/5+1/5(3)	2+1/6+2/3+1/5(3)	2+1/6+2/3+1/5(3)	3+1/8+2/5+1/5(3)	3+1/7+2/4+1/5(3)
Setal formula of Th. VII	2+1/6+2/4+1/4(2)	2+1/5+2/4+1/5(3)	1+1/5+2/2+1/4(2)	2+1/5+2/3+1/5(3)	2+1/5+2/4+1/5(3)	2+1/5+2/4+1/5(3)
Uropod						
No. of spines on sympod	20	18	18	16	18	17
No. of setae on exopod	10	11	11	9	11	10
Furcal rami						
No. of spines on inner margin	9, 10	8	10	9	10	9

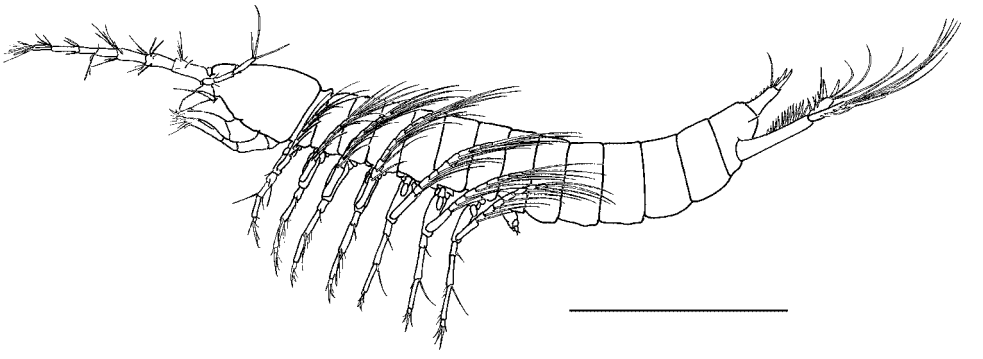

Figure 19. General habitus of *Brevisomabathynella jundeeensis* sp. nov. (♂, holotype). Scale bar 1 mm.

Type locality

Australia, Western Australia, Gascoyne, Jundee Station, JSP 10, South Hill Well BF, Jundee Mine (26°16′58″ S, 120°40′33″ E), BES 6580, 11 May 2001, leg. W.F. Humphreys C.H.S. Watts and S.J.B. Cooper.

Other locality

One adult male and one adult female, each dissected on five slides (WAM C 40282, C 40890), Jundee Station, bore next to "sacred" well Jundee soak (26°21′22″ S, 120°38′56″ E), BES 6474, 10 May 2001, leg. W.F. Humphreys, C.H.S. Watts and S.J.B. Cooper; two females, one dissected on five slides, one as a whole specimen in a slide (WAM C 40283, C 40891), Jundee Station, JSP1 South Hill Well BF, Jundee Mine (26°16′58″ S, 120°40′33″ E), BES 6578(6579), 11 May 2001, leg. W.F. Humphreys, C.H.S. Watts and S.J.B. Cooper; one male and one female, each as a whole specimen on separate slides (WAM C 40284, C 40892), Jundee Station, OB behind JSP12 South Hill Well BF, Jundee Mine (26°17′14″ S, 120°40′16″ E), BES 6587, 11 May 2001, leg. W.F. Humphreys, C.H.S. Watts and S.J.B. Cooper; one male, as a whole specimen on a slide (WAM C 40285), Jundee Station. JE150 South Hill Well BF, Jundee Mine (26°16′58″ S, 120°40′33″ E), BES 6598, 11 May 2001, leg. W.F. Humphreys, C.H.S. Watts and S.J.B. Cooper.

Description of adult male (holotype)

Body. Length 3.42 mm (Figure 19). Head as long as anterior three thoracic segments 1–3 combined, approximately 10 times as long as wide

Antennule (Figure 20A,B). Seven-segmented. First segment with one seta on inner margin, with three simple dorsal setae and with one dorsal, one ventromedial and two lateral plumose setae. Second segment with one group of four plumose setae and with four (left) or six (right) simple setae on inner margin (Figure 20B). Third segment with three lateral setae including one plumose seta and six setae on inner margin. Inner flagellum of third segment with three simple setae. Fourth segment

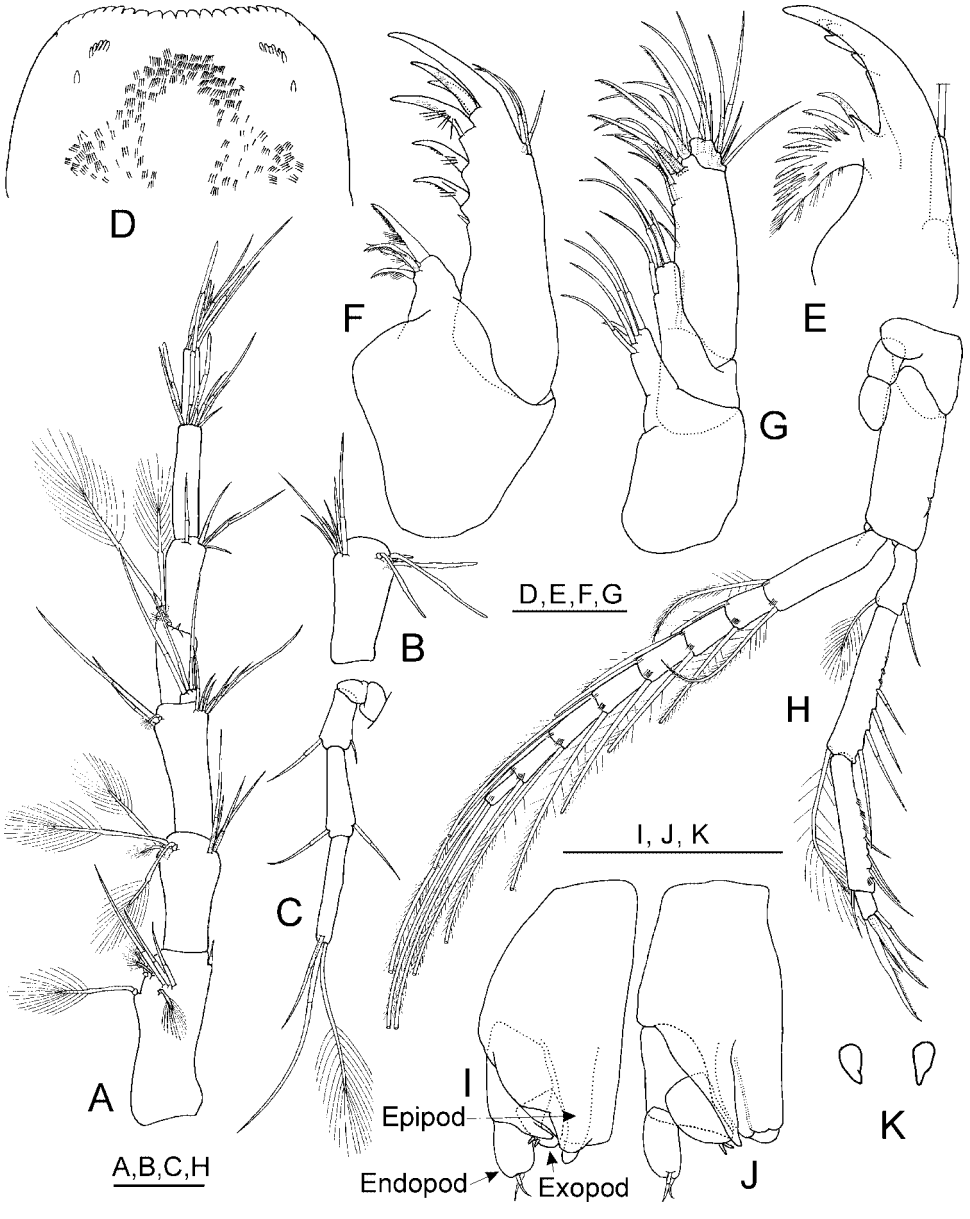

Figure 20. *Brevisomabathynella jundeeensis* sp. nov. (♂, holotype; ♀, allotype): (A) left antennule ♂ (dorsal); (B) second segment of right antennule ♂ (dorsal); (C) left antennla ♂ (dorsal); (D) labrum ♂ (ventral); (E) left mandible ♂ (ventral); (F) left maxillule I ♂ (ventral); (G) right maxilla (dorsal); (H) right thoracopod VII ♂ (frontal); (I) left thoracopod VIII ♂ (inner lateral); (J) right thoracopod VIII ♂ (frontal); (K) right and left thoracopods VIII ♀. Scale bars 0.1 mm.

with one stub seta and one plumose seta on dorsal margin, and with two stub setae and two plumose setae on outer distal apophysis. Fifth segment with four setae on inner margin and one dorsal seta. Sixth segment with four setae on inner

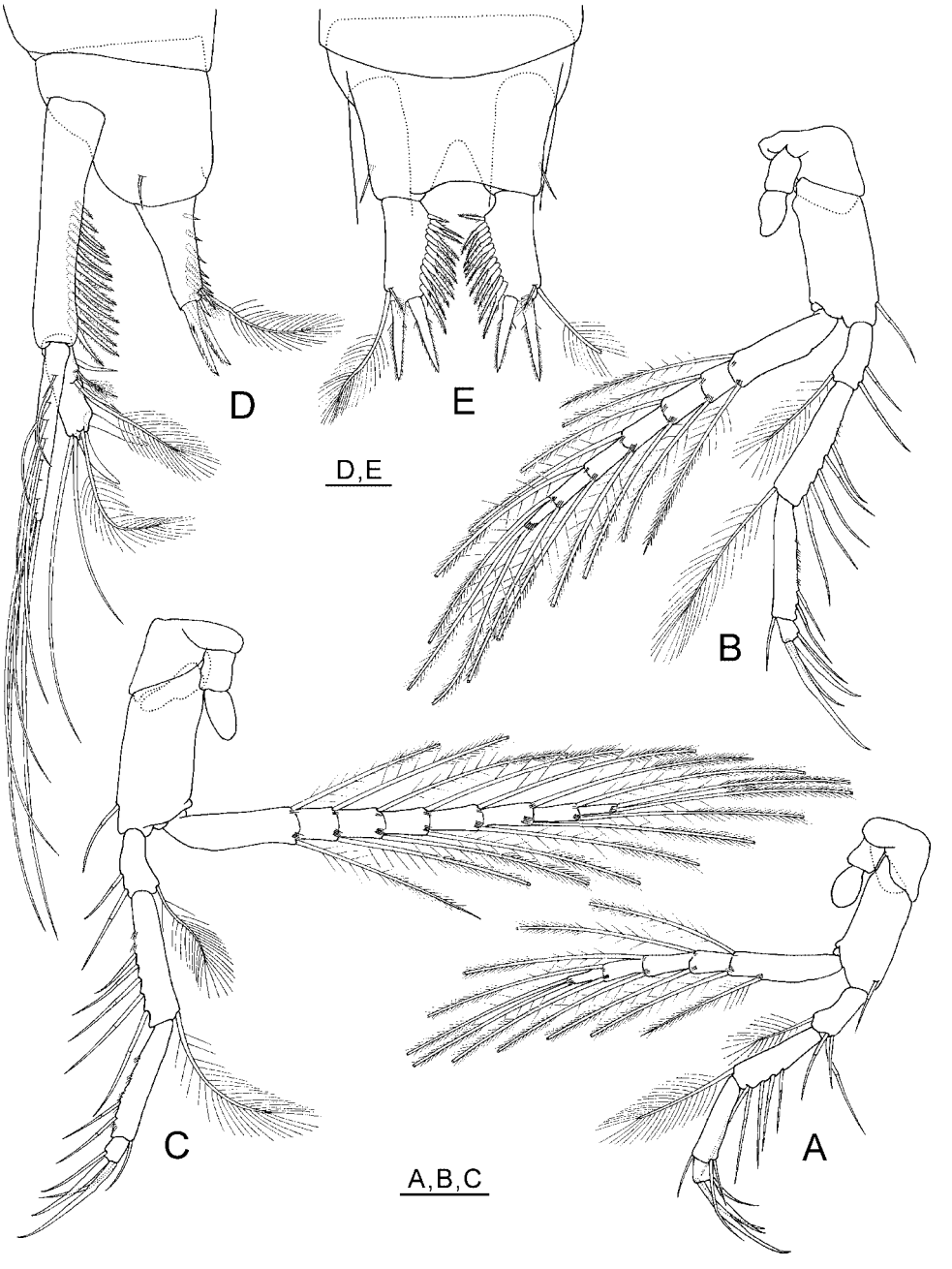

Figure 21. *Brevisomabathynella jundeeensis* sp. nov. (♂, holotype): (A) right thoracopod I (frontal); (B) right thoracopod II (frontal); (C) left thoracopod III (frontal); (D) pleotelson, furcal rami and uropod (lateral); (E) pleotelson and furcal rami (dorsal). Scale bars 0.1 mm.

margin and with dorsal group of two aesthetascs, one simple seta and one additional aesthetasc lateral to simple seta. Seventh segment with three subterminal aesthetascs and four simple setae.

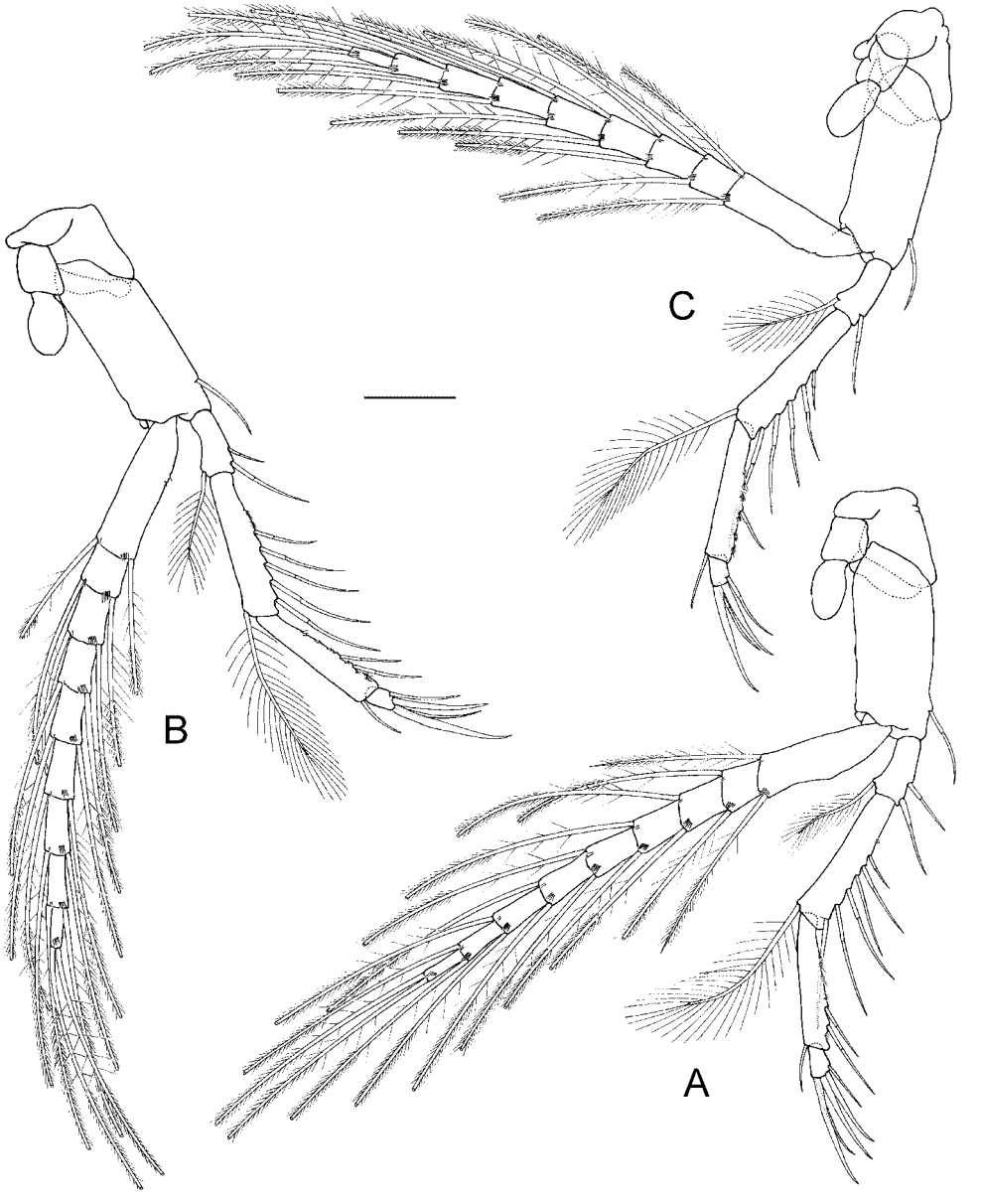

Figure 22. *Brevisomabathynella jundeeensis* sp. nov. (♂, holotype): (A) right thoracopod IV (frontal); (B) right thoracopod V (frontal); (C) left thoracopod VI (frontal). Scale bar 0.1 mm.

Antenna (Figure 20C). Five-segmented, as long as antennular segments 1–3 combined. Fourth segment slightly shorter than fifth segment. Setal formula: 0+0/0+0/1+1/1+1/3(1). Plumose seta of distal segment shorter than longest simple seta.

Labrum (Figure 20D). Flat, with total 24 teeth. Twelve median teeth of more or less similar size flanked by six teeth decreasing in size laterally. Ventral surface with numerous combs of ctenidia and teats.

Mandible (Figure 20E). Incisor process of six teeth. Tooth of ventral edge triangular. Spine row consisting of 12 spines. Palp of one segment, with one apical seta.

Maxillule (Figure 20F). Two-segmented. Proximal segment with four setae on inner margin. Distal segment with two terminal spines, with four spines with denticles and one tiny proximal spine on inner edge, and with three simple setae on outer margin.

Maxilla (Figure 20G). Four-segmented, setal formula 5-5-11-9.

Thoracopods I–VII (Figures 20H, 21A–C, 22A–C). Thoracopods I–IV increasing in size posteriorly. Thoracopods IV–VII similar in size. Thoracopods I–VII each with one epipod on protopod, and with one seta on basipod. Number of exopodal segments of thoracopods I–VII: 5-7-8-9-9-9-8. Endopod of thoracopods I–VII four-segmented, setal formulae:

Th. I	3+1/5+1/2+1/4(2)
Th. II, III	2+1/5+1/2+1/4(2)
Th. IV	2+1/6+1/2+1/5(3)
Th. V	2+1/5+1/2+1/4(2)
Th. VI	1+1/5+1/1+1/4(2)
Th. VII	1+1/4+1/3+1/4(2)

Thoracopod VIII (Figure 20I,J). More or less rectangular in frontal view, twice as long as wide. Protopod massive, with prominent penial region with terminal opening. Epipod large, conical, distal part barely reaching penial region of protopod. Basipod without setae, inner margin of basipod drawn out into projection. Exopod one-third size of basipod, triangular, bearing two subterminal setae. Endopod as long as exopod, with two terminal setae.

First pleopod. Absent.

Uropod (Figure 21D). Fifteen spines on inner margin of sympod. Exopod 70% as long as sympod, with 11 setae on outer and terminal margin, without basiventral setae. Endopod 41% as long as sympod, with two dorsal plumose setae near base, with two terminal setae and one subterminal plumose seta on outer margin, and with one terminal, one subterminal and three additional spines on inner margin. Terminal and subterminal spines similar in size. Three inner-marginal spines spike-like, two-thirds as long as terminal spines and thin.

Pleotelson (Figure 21D,E). One seta near base of each furcal ramus on both sides. Anal operculum concave.

Furcal rami (Figure 21D,E). Twice as long as width, with two large terminal spines, and 12 spines on inner margin, and with two dorsal setae.

Description of adult female (allotype)

Body. Length 3.33 mm. Identical to male except for following characters.

Antennule. Second segment with six setae on inner margin, no difference between right and left antennules.

Mandible. Spine row consisting of nine spines.

Maxilla. Setal formula: 4-5-11-9

Thoracopods I–VII. Number of exopodal segments of thoracopods I–VII: 5-6-7-8-8-8-7. Setal formulae of endopods:

Th. I	3+1/4+1/2+1/4(2)
Th. II, III	2+1/4+1/1+1/4(2)
Th. IV–VI	1+1/4+1/1+1/4(2)
Th. VII	1+1/3+1/1+1/4(2)

Thoracopod VIII (Figure 20K). Conical, half as long as endopod of male thoracopod VIII, with one terminal tooth.

Uropod. Sympod with 14 spines. Exopod with 12 setae.

Furcal rami. Eleven spines on inner margin.

Intraspecific variation

Range of body length: male 3.07–3.42 mm; female 2.89–3.33 mm. Variation in number of setae, spines or segments as listed in Table 4.

Etymology

The specific name refers to Jundee Pastoral Station.

Brevisomabathynella parooensis **sp. nov.**

(Figures 23–25)

Material examined

Holotype (adult male), allotype (adult female), paratypes (each one adult male and female). Holotype: dissected on five slides (WAM C 40286). Allotype: dissected on five slides (WAM C 40287). Paratypes: one adult male and one adult female each dissected on five slides (WAM C 40288–C 40289).

Table 4. Intraspecific variation of *Brevisomabathynella jundeeensis* sp. nov. (data acquired from the eight dissected specimens).

	Holotype (♂)	Allotype (♀)	Paratype 1 (♂)	Paratype 2 (♂)	Paratype 3 (♂)	Paratype 4 (♀)	Paratype 5 (♀)	Paratype 6 (♀)
Body length (mm)	3.42	3.33	3.38	3.13	3.07	3.32	3.33	3.30
Antennule (segments)								
First segment: no. dorsal setae	3	3	3	2	2	3	3	3
Second segment: no. setae on inner distal margin	4, 6	6	5	5	4	5	7	7
Third segment: no. setae on inner distal margin	6	6	6	5	5	6	6	6
Fifth segment: no. of setae on inner distal margin	5	5	5	4	4	4	4	4
No. of spines of spine row of mandible	13	11	10	9	8	11	11	11
Setal formula of maxilla	5-5-11-9	4-5-11-9	5-5-11-9	4-5-11-9	2-4-10-8	4-5-11-9	4-6-12-9	4-6-12-9
Thoracopods I–VII								
No. of exopodal segments	5-7-8-9-9-9-8	5-6-7-8-8-8-7	5-6-7-8-8-7-7	4-6-6-7-7-7-6	3-4-5-5-5-5-4	5-6-7-7-7-7-7	5-6-8-8-9-8-8	5-6-8-8-9-8-8
Setal formula of Th. I	3+1/5+1/2 +1/4(2)	3+1/4+1/2 +1/4(2)	3+1/4+1/2 +1/4(2)	3+1/4+1/2 +1/4(2)	2+1/3+1/1 +1/4(2)	3+1/4+1/2 +1/4(2)	3+1/5+1/2 +1/4(2)	3+1/5 +1/2+1/4(2)
Setal formula of Th. II	2+1/5+1/2 +1/4(2)	2+1/4+1/1 +1/4(2)	2+1/4+1/2 +1/4(2)	2+1/3+1/1 +1/4(2)	1+1/2+1/0 +1/4(2)	2+1/5+1/2 +1/4(2)	2+1/5+1/2 +1/5(3)	2+1/5+1/2 +1/5(3)
Setal formula of Th. III	2+1/5+1/2 +1/5(3)	2+1/4+1/1 +1/4(2)	2+1/4+1/1 +1/4(2)	2+1/3+1/1 +1/4(2)	1+1/3+1/0 +1/4(2)	2+1/5+1/2 +1/4(2)	2+1/4+1/2 +1/5(3)	2+1/4+1/2 +1/5(3)
Setal formula of Th. IV	2+1/6+1/2 +1/4(2)	1+1/4+1/1 +1/4(2)	1+1/5+1/1 +1/4(2)	2+1/4+1/1 +1/4(2)	1+1/3+1/0 +1/4(2)	1+1/5+1/2 +1/4(2)	1+1/5+1/2 +1/5(3)	1+1/5+1/2 +1/5(3)

(*Continued*)

Table 4. (Continued).

	Holotype (♂)	Allotype (♀)	Paratype 1 (♂)	Paratype 2 (♂)	Paratype 3 (♂)	Paratype 4 (♀)	Paratype 5 (♀)	Paratype 6 (♀)
Setal formula of Th. V	2+1/5+1/2 +1/4(2)	1+1/4+1/1 +1/4(2)	1+1/5+1/1 +1/4(2)	1+1/3+1/1 +1/4(2)	1+1/3+1/0 +1/4(2)	1+1/4+1/2 +1/4(2)	1+1/5+1/2 +1/5(3)	1+1/5+1/2 +1/5(3)
Setal formula of Th. VI	1+1/5+1/1 +1/4(2)	1+1/4+1/1 +1/4(2)	1+1/4+1/1 +1/4(2)	1+1/3+1/1 +1/4(2)	1+1/2+1/0 +1/4(2)	1+1/4+1/2 +1/4(2)	1+1/4+1/2 +1/4(2)	1+1/4+1/2 +1/4(2)
Setal formula of Th. VII	1+1/4+1/3 +1/4(2)	1+1/3+1/1 +1/4(2)	1+1/3+1/1 +1/4(2)	1+1/2+1/1 +1/4(2)	0+1/2+1/0 +1/4(2)	1+1/3+1/2 +1/4(2)	1+1/4+1/2 +1/4(2)	1+1/4+1/2 +1/4(2)
Uropod								
No. of spines on sympod	15	14	15	15	11	15	14	14
No. of setae on exopod	11	12	11	10	6	10	12	12
Furcal rami								
No. of spines on inner margin	12	11	11	10	4	12	9	9

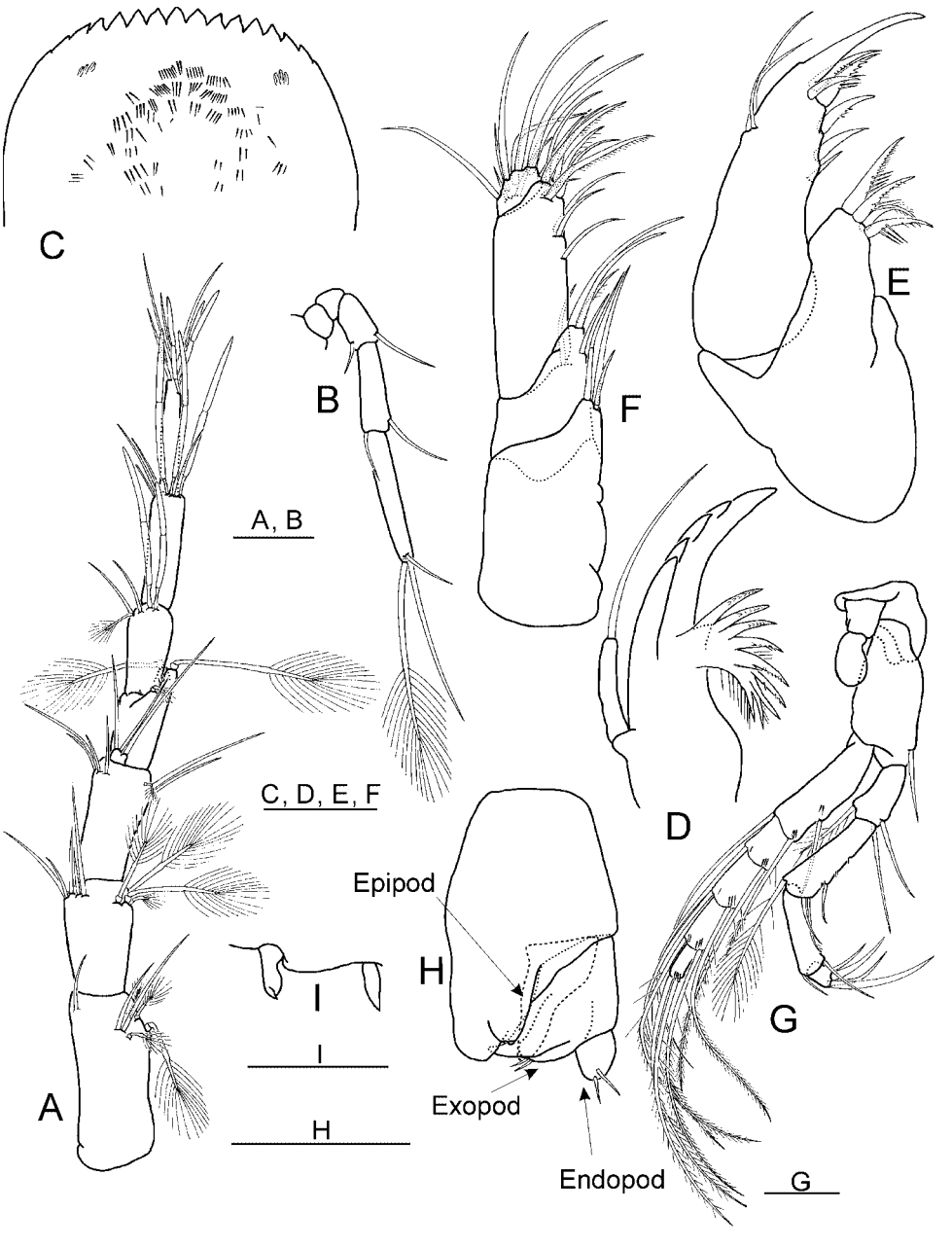

Figure 23. *Brevisomabathynella parooensis* sp. nov. (♂, holotype; ♀, allotype): (A) right antennule ♂ (dorsal); (B) right antenna ♂ (dorsal); (C) labrum ♂ (ventral); (D) left mandible ♂ (dorsal); (E) left maxillule ♂ (dorsal); (F) left maxilla (dorsal); (G) right thoracopod I ♂ (frontal); (H) right thoracopod VIII ♂ (inner lateral); (I) right and left thoracopods VIII ♀. Scale bars 0.05 mm.

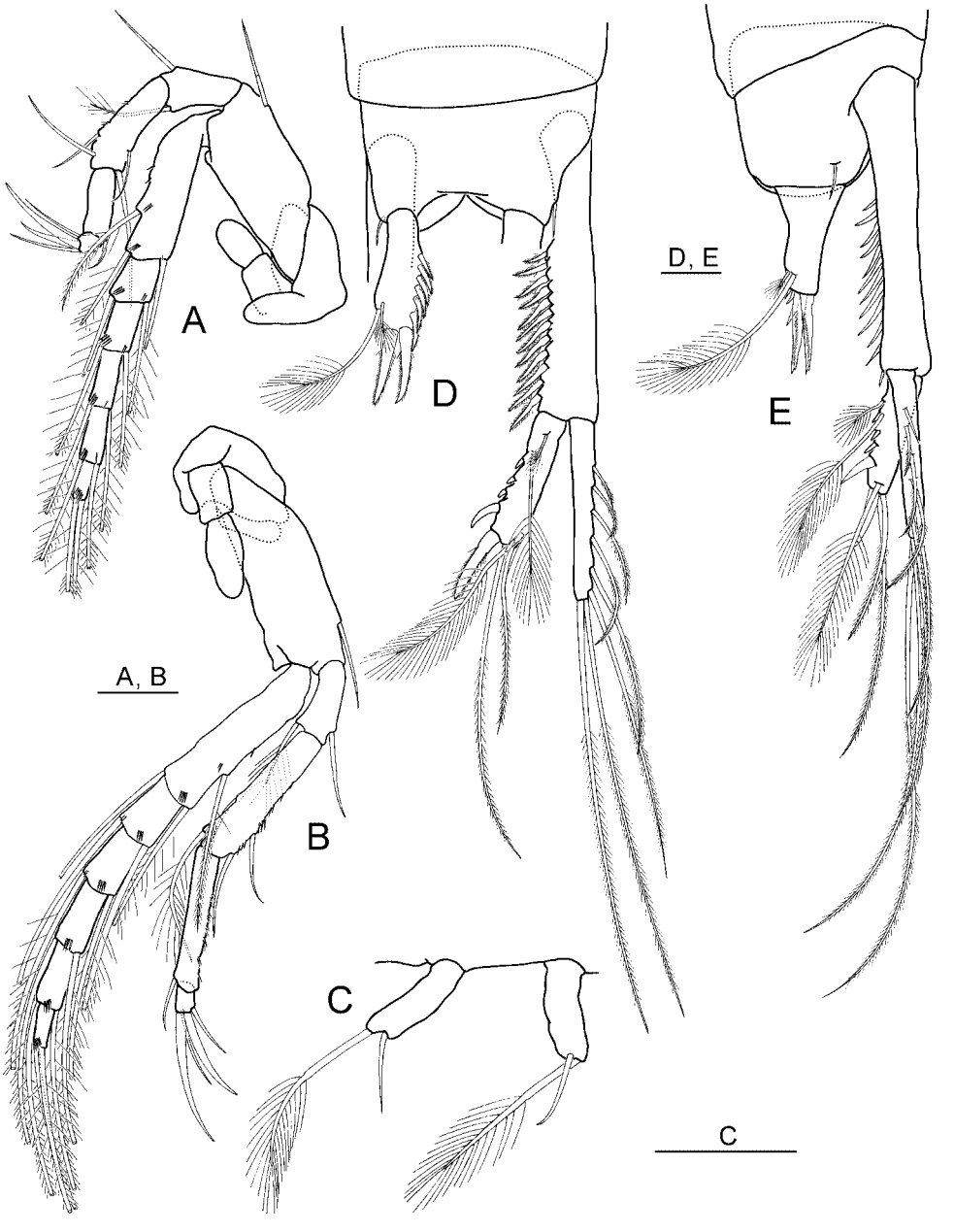

Figure 24. *Brevisomabathynella parooensis* sp. nov. (♂, holotype): (A) left thoracopod II ♂ (frontal); (B) right thoracopod VI ♂ (frontal); (C) pleopod I ♂ (ventral); (D) pleotelson, furcal rami and uropod ♂ (dorsal); (E) pleotelson, furcal rami and uropod ♂ (lateral). Scale bars 0.05 mm.

Type locality

Australia, Western Australia, Carey Palaeodrainage, Paroo Station GSWA 15 South (26°24′01″ S, 119°45′47″ E), BES 5620, 5 July 2001, leg. W.F. Humphreys, C.H.S. Watts and S.J.B.Cooper.

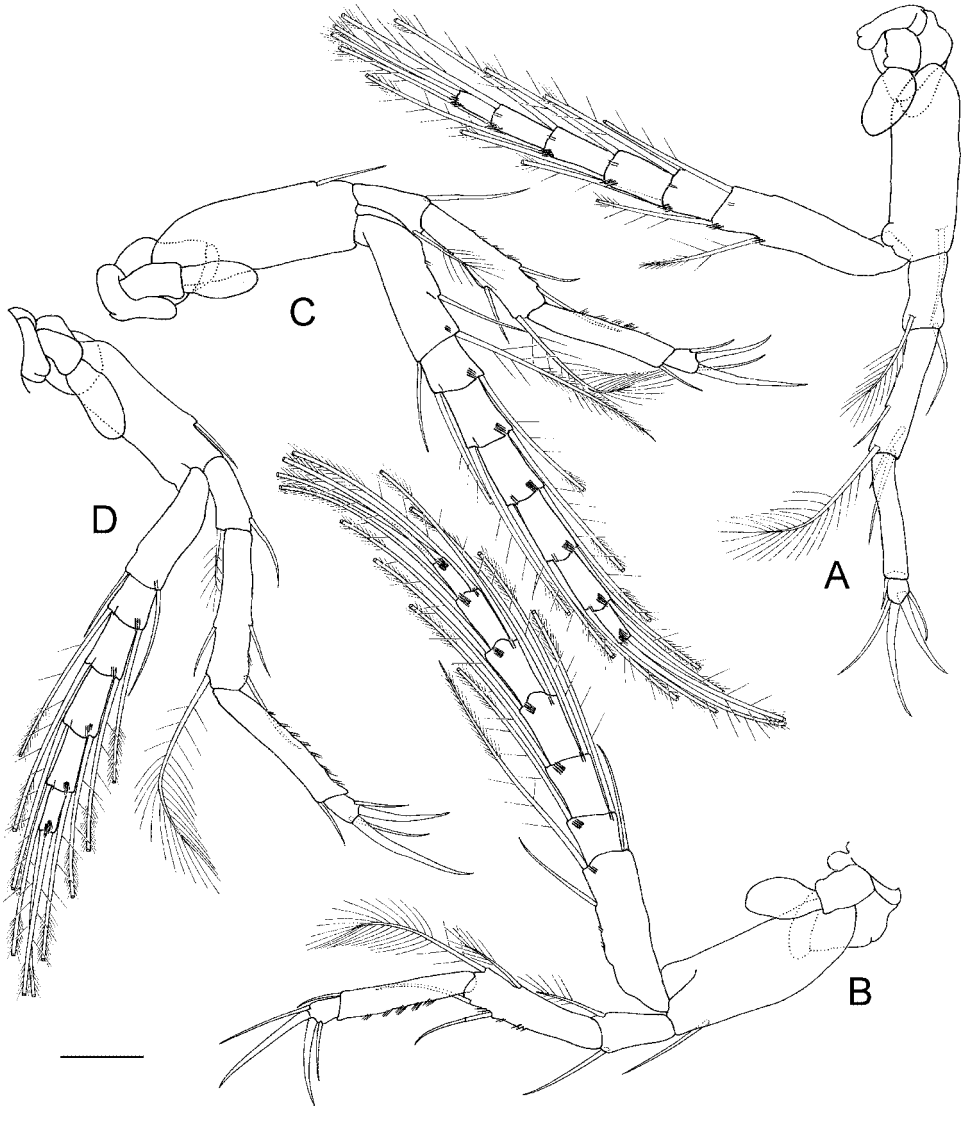

Figure 25. *Brevisomabathynella parooensis* sp. nov. (♂, holotype): (A) right thoracopod III (frontal); (B) right thoracopod IV (frontal); (C) right thoracopod V (frontal); (D) right thoracopod VII (frontal). Scale bar 0.05 mm.

Description of adult male (holotype)

Body. Length 2.01 mm. Head as long as anterior three thoracic segments 1–3 combined, approximately 10 times as long as wide

Antennule (Figure 23A). Seven-segmented. First segment with one seta on inner margin, with two simple dorsal setae and with one dorsal, one ventromedial and two lateral plumose setae. Second segment with one group of four plumose setae and with five simple setae on inner margin. Third segment with three lateral setae including

one plumose seta and four setae on inner margin. Inner flagellum of third segment with three simple setae. Fourth segment with one stub seta and one plumose seta on dorsal margin, and with two stub setae and two plumose setae on outer distal apophysis. Fifth segment with one simple seta and one plumose seta on inner margin, and with one dorsal simple seta and two aesthetascs. Sixth segment with four setae on inner margin and with dorsal group of two aesthetascs, one simple seta and one additional aesthetasc lateral to simple seta. Seventh segment with three subterminal aesthetascs and four simple setae.

Antenna (Figure 23B). Five-segmented, as long as antennular segments 1–3 combined. Fourth segment slightly shorter than fifth segment. Setal formula: 0+0/0+0/1+1/1+1/3(1). Plumose seta of distal segment longer than longest simple seta.

Labrum (Figure 23C). Flat, with eight teeth of more or less similar size flanked by four teeth decreasing in size laterally on each side. Ventral surface with six teats and numerous combs of ctenidia.

Mandible (Figure 23D). Incisor process of five teeth. Tooth of ventral edge triangular. Spine row consisting of nine spines. Palp of one segment, with one apical seta.

Maxillule (Figure 23E). Two-segmented. Proximal segment with four setae on inner margin. Distal segment with two terminal spines and five inner spines with denticles, of which most proximal is weak, and with three simple setae of different size on outer margin.

Maxilla (Figure 23F). Four-segmented, setal formula 3-5-11-9.

Thoracopods I–VII (Figures 23G, 24A,B, 25A–D). Thoracopods I–IV increasing in size posteriorly. Thoracopods IV–VII similar in size. Thoracopods I–VII each bearing one epipod on protopod. Basipod of thoracopods I–VII with one seta. Number of exopodal segments of thoracopods I–VII: 5-6-6-7-7-6-6. Endopod of thoracopods I–VII four-segmented, setal formulae:

Th. I	2+1/3+1/1+1/4(2)
Th. II–VII	1+1/2+2/0+1/4(2)

Thoracopod VIII (Figure 23H). Rectangular in frontal view, 1.5 times as long as wide. Protopod massive, with prominent penial region. Epipod large, triangular, distal part barely reaching terminal end of penial region. Basipod without setae, inner margin of basipod drawn out into projection. Exopod one-third size of basipod, triangular, with four to five terminal teeth and two subterminal setae. Endopod one-half size of exopod, with two terminal seta.

First pleopod (Figure 24C). In form of two small stubs separated from each other. Each stub bearing two terminal seta.

Uropod (Figure 24D,E). Twelve spines of similar size on inner margin of sympod. Exopod 60% as long as sympod, with eight setae on outer and terminal margin, without

basiventral setae. Endopod 44% as long as sympod, with two dorsal plumose setae near base, with two terminal setae and one subterminal plumose seta on outer margin, and with one terminal, one subterminal and three additional spines on inner margin. Terminal spine twice as long and thick as subterminal spine. Three inner spines tiny, tooth-like.

Pleotelson (Figure 24D,E). One seta near base of each furcal ramus on both sides. Anal operculum flat.

Furcal rami (Figure 24D,E). Twice as long as wide, with two large terminal spines, and six smaller spines on inner margin, and with two dorsal setae.

Description of adult female (allotype)

Body. Length 1.97 mm. Identical to male except for following characters.

Antennule. Fifth segment with three setae on inner margin.

Maxilla. Setal formula: 4-5-11-9.

Thoracopods I–VII. Number of exopodal segments of thoracopods I–VII: 5-6-7-7-7-7-6.

Thoracopod VIII (Figure 23I). Conical, half as long as endopod of male thoracopod VIII, with one terminal tooth.

Uropod. Exopod with eight setae.

Intraspecific variation

Body length of paratypes: male 1.90 mm; female 1.67 mm. Variation in number of setae, spines or segments of extremities as listed in Table 5.

Etymology

The specific name refers to Paroo Pastoral Station.

***Brevisomabathynella eberhardi* sp. nov.**

(Figures 26–29)

Material examined

Holotype (adult male), allotype (adult female), paratypes (each one adult male and female). Holotype: dissected on seven slides (WAM C 40290). Allotype: dissected on four slides (WAM C 40291). Paratypes: one adult male and one adult female each as a whole specimen on a slide (WAM C 40292–C 40293).

Type locality

Australia, Western Australia, Paroo station, GSWA Bore #20(A) (26°20′44″ S, 119°35′22″ E), BES 6063, 6 June 1998, leg. S.M. Eberhard.

Table 5. Intraspecific variation of *Brevisomabathynella parooensis* sp. nov. (data acquired from the four dissected specimens).

	Holotype (♂)	Allotype (♀)	Paratype 1 (♀)	Paratype 2 (♂)
Body length (mm)	2.01	1.97	1.90	1.67
Antennule (segments)				
Second segment: no. setae on inner distal margin	5	5	5	4
Fifth segment: no. of setae on inner distal margin	2	3	3	3
Setal formula of maxilla	3-5-11-9	4-5-11-9	3-4-11-9	3-5-11-9
Thoracopods I–VII				
No. of exopodal segments	5-6-6-7-7-6-6	5-6-7-7-7-7-6	4-5-6-6-6-6-5	4-5-5-5-5-5-4
Uropod				
No. of spines on sympod	12	12	12	10
No. of setae on exopod	9	8	7	5
Furcal rami				
No. of spines on inner margin	6	6	6	5

Description of adult male (holotype)

Body. Length 1.82 mm (Figure 26A). Head as long as anterior three thoracic segments 1–3 combined, approximately 10 times as long as wide.

Antennule (Figure 26B). Seven-segmented. First segment with one seta on inner margin, with three simple dorsal setae and with one dorsal, one ventromedial and two lateral plumose setae. Second segment with one group of four plumose setae and with five simple setae on inner margin. Third segment with three lateral setae including one plumose seta and four setae on inner margin. Inner flagellum of third segment with three simple setae. Fourth segment with one stub seta and one plumose seta on dorsal margin, and with two stub setae and two plumose setae on outer distal apophysis. Fifth segment with four setae on inner margin and one dorsal seta. Sixth segment with four setae on inner margin and with dorsal group of two aesthetascs, one simple seta and one additional aesthetasc lateral to simple seta. Seventh segment with three subterminal aesthetascs and four simple setae.

Antenna (Figure 26C). Five-segmented, as long as antennular segments 1–3 combined. Fourth segment slightly shorter than fifth segment. Setal formula: 0+0/0+0/1+1/1+1/3(1). Plumose seta of distal segment as long as longest simple seta.

Labrum (Figure 26D). Flat with 10 median teeth of more or less similar size flanked by four smaller teeth on each side. Ventral surface with numerous combs of ctenidia and three teats.

Mandible (Figure 26E). Incisor process of five teeth. Tooth of ventral edge triangular. Spine row consisting of nine spines. Palp of one segment, with one apical seta.

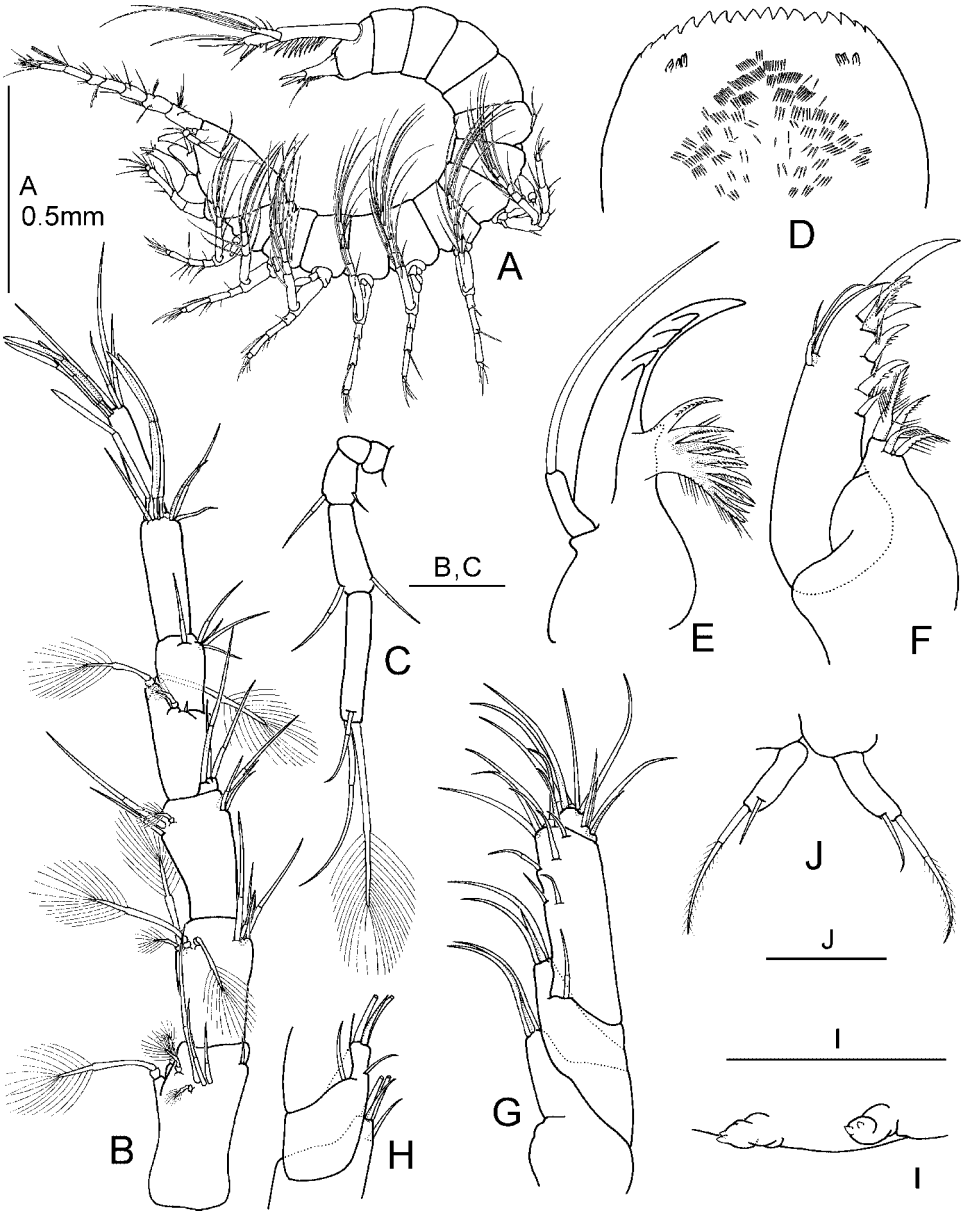

Figure 26. *Brevisomabathynella eberhardi* sp. nov. (♂, holotype; ♀, allotype): (A) general habitus ♂; (B) left antennule ♂ (dorsal); (C) left antenna ♂ (dorsal); (D) labrum ♂ (ventral); (E) left mandible ♂ (dorsal); (F) left maxillule ♂ (dorsal); (G) right maxilla ♂ (dorsal); (H) first and second segments of left maxilla (dorsal); (I) right and left thoracopods VIII ♀ (ventral); (J) pleopod I ♂ (ventral). Scale bars 0.05 mm (unless otherwise specified).

Maxillule (Figure 26F). Two-segmented. Proximal segment with four setae on inner margin. Distal segment with two terminal spines, with five spines with denticles on inner edge, and with three simple setae on outer margin.

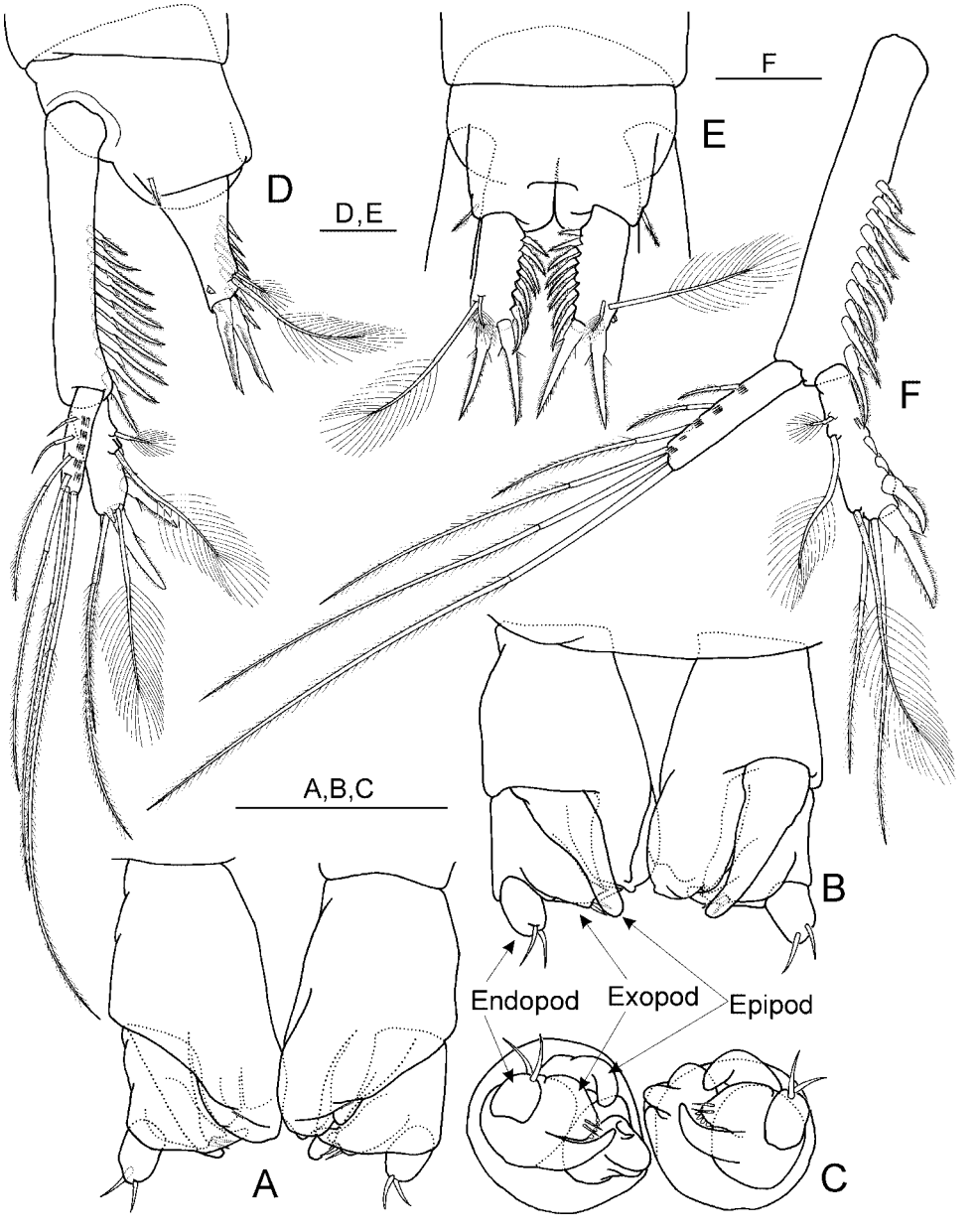

Figure 27. *Brevisomabathynella eberhardi* sp. nov. (♂, holotype): (A) right and left thoracopods VIII (posterior); (B) right and left thoracopods VIII (frontal); (C) right and left thoracopods VIII (ventral); (D) pleotelson, furcal rami and uropod (lateral); (E) pleotelson and furcal rami (dorsal); (F) uropod (dorsal). Scale bars 0.05 mm.

Maxilla (Figure 26G). Four-segmented, setal formula 3,4-4-11-9.

Thoracopods I–VII (Figures 28A–D, 29A–C). Thoracopods I–IV increasing in size posteriorly. Thoracopods IV–VII similar in size. Thoracopods I–VII each bearing

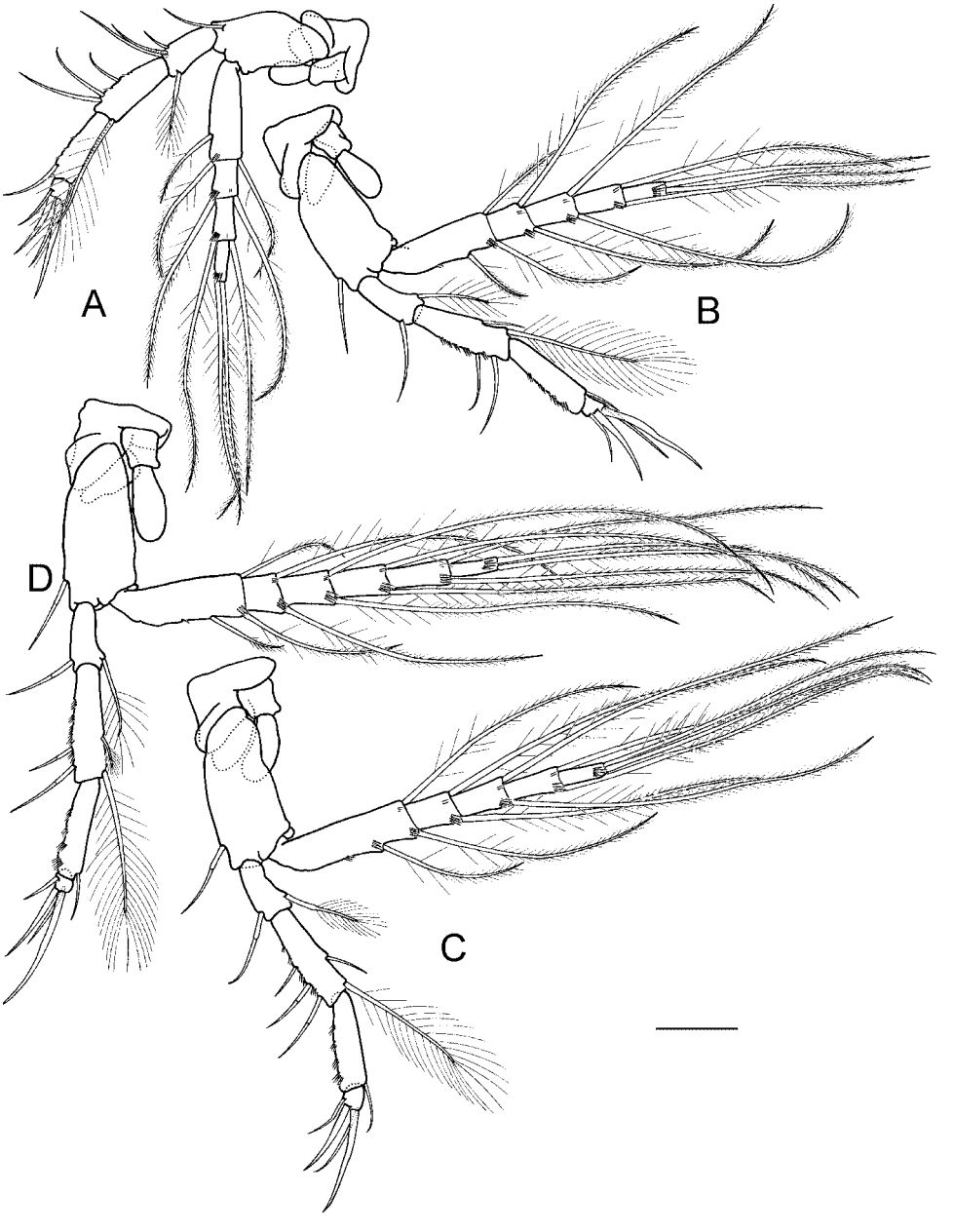

Figure 28. *Brevisomabathynella eberhardi* sp. nov. (♂, holotype): (A) left thoracopod I (frontal); (B) left thoracopod II (frontal); (C) left thoracopod III (frontal); (D) left thoracopod IV (frontal). Scale bar 0.05 mm.

one epipod on protopod. Basipod of thoracopods I–VII with one seta. Number of exopodal segments of thoracopods I–VII: 4-5-5-6-6-5-5. Endopod of thoracopods I–VII four-segmented, setal formulae:

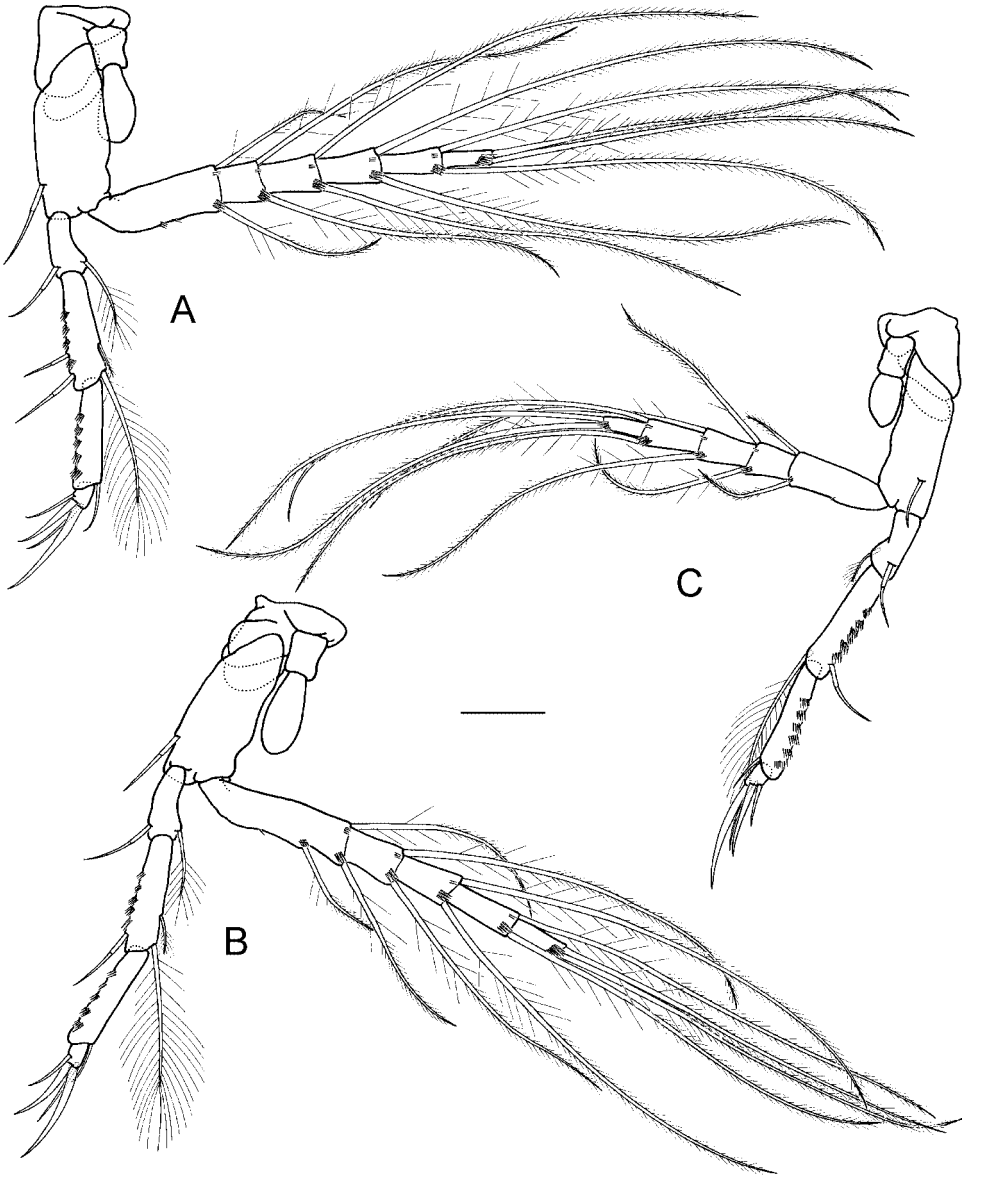

Figure 29. *Brevisomabathynella eberhardi* sp. nov. (♂, holotype): (A) left thoracopod V (frontal); (B) left thoracopod VI (frontal); (C) right thoracopod VII (frontal). Scale bar 0.05 mm.

Th. I	3+1/3+1/1+1/4(2)
Th. II	1+1/2+2/0+1/4(2)
Th. III	1+1/3+2/0+1/4(2)
Th. IV, V	1+1/2+2/0+1/4(2)
Th. VI	1+1/1+2/0+1/4(2)
Th. VII	1+1/1+1/0+1/4(2)

Thoracopod VIII (Figure 27A–C). Rectangular in frontal view, twice as long as wide. Protopod massive, with prominent penial region with terminal opening. Epipod large, triangular, distal part reaching terminal region of basipod. Basipod without setae, inner margin of basipod drawn out into projection. Exopod one-third size of basipod, triangular, bearing four terminal teeth and two subterminal setae. Endopod as long as exopod, with two terminal setae.

First pleopod (Figure 26J). In form of two stubs adjacent to each other. Each stub bearing two terminal setae.

Uropod (Figure 27D,F). Ten spines on inner margin of sympod. Exopod as long as endopod, with six setae on outer and terminal margin, without basiventral setae. Endopod 45% as long as sympod, with two dorsal plumose seta near base, with two terminal setae and one subterminal plumose seta on outer margin, and with one terminal, one subterminal and two additional spines on inner margin. Terminal spine somewhat longer and thicker than subterminal spine. Two inner-marginal spine tiny, tooth-like.

Pleotelson (Figure 27D,E). One seta near base of each furcal ramus on both sides. Anal operculum concave.

Furcal rami (Figure 27D,E). Twice as long as wide, with two large terminal spines, seven (left) or eight (right) additional spines on inner margin, and with two dorsal setae.

Description of adult female (allotype)

Body. Length 1.75 mm. Identical to male except for following characters.

Antennule. Second segment with four setae on inner margin. Third segment with five setae on inner margin.

Thoracopods I–VII. Number of exopodal segments of thoracopods I–VII: 5-5-6-6-6-5-5. Setal formulae of endopods:

Th. I	3+1/3+1/1+1/4(2)
Th. II – V	1+1/3+2/0+1/4(2)
Th. VI, VII	1+1/2+2/0+1/4(2)

Thoracopod VIII (Figure 26I). Conical, half as long as endopod of male thoracopod VIII, with one terminal tooth.

Furcal rami. Both right and left furcal rami with seven spines on inner margin.

Intraspecific variation

Body length of paratypes: male 1.77 mm; female 1.67 mm. Variation in number of setae, spines or segments of extremities as listed in Table 6.

Etymology

The specific name refers to one of the collectors, Dr S.M. Eberhard (Perth, Australia).

Table 6. Intraspecific variation of *Brevisomabathynella eberhardi* sp. nov. (data acquired from the four dissected specimens).

	Holotype (♂)	Allotype (♀)	Paratype 1 (♂)	Paratype 2 (♀)
Body length (mm)	1.82	1.75	1.77	1.67
Antennule (segments)				
First segment: no. dorsal setae	3	4	3	3
Second segment: no. setae on inner distal margin	5	4	5	5
Third segment: no. setae on inner distal margin	4	5	4	4
Fifth segment: no. of setae on inner distal margin	4	4	3	3
Thoracopods I–VII				
No. of exopodal segments	4-5-5-6-6-5-5	5-5-6-6-6-5-5	4-5-6-6-6-6-5	3-4-5-5-5-5-4
Setal formula of Th. I	3+1/3+1/1+1/4(2)	3+1/3+1/1+1/4(2)	3+1/2+1/1+1/4(2)	3+1/2+1/1+1/4(2)
Setal formula of Th. II	1+1/2+2/0+1/4(2)	1+1/3+2/0+1/4(2)	1+1/3+2/0+1/4(2)	1+1/2+2/0+1/4(2)
Setal formula of Th. III	1+1/3+2/0+1/4(2)	1+1/3+2/0+1/4(2)	1+1/1+2/0+1/4(2)	1+1/1+2/0+1/4(2)
Setal formula of Th. IV	1+1/2+2/0+1/4(2)	1+1/3+2/0+1/4(2)	1+1/1+2/0+1/4(2)	1+1/1+2/0+1/4(2)
Setal formula of Th. V	1+1/2+2/0+1/4(2)	1+1/3+2/0+1/4(2)	1+1/1+2/0+1/4(2)	1+1/1+2/0+1/4(2)
Setal formula of Th. VI	1+1/1+2/0+1/4(2)	1+1/2+2/0+1/4(2)	1+1/1+2/0+1/4(2)	1+1/1+2/0+1/4(2)
Setal formula of Th. VII	1+1/1+1/0+1/4(2)	1+1/2+2/0+1/4(2)	1+1/1+2/0+1/4(2)	1+1/1+2/0+1/4(2)
Uropod				
No. of spines on sympod	10	10	11	10
No. of setae on exopod	6	6	7	5
Furcal rami				
No. of spines on inner margin	7,8	7	7	7

***Brevisomabathynella leijsi* sp. nov.**
(Figures 30–33)

Material examined

Holotype (adult male), allotype (adult female), paratype (six adult males and four adult females). Holotype: dissected on five slides (WAM C 40300). Allotype: dissected on five slides (WAM C 40301). Paratypes: one male dissected on five slides (WAM C 40302), five males and four females each as a whole specimen in a slide (WAM C 40303–C 40311).

Type locality

Australia, Western Australia, Nabberu Palaeodrainage, Cunyu Station, SBF calcrete, MEB site 36 (25°46′51″ S, 120°06′27″ E), BES 12859, 6 April 2005, leg. W.F. Humphreys and R. Leijs.

Description of adult male (holotype)

Body. Length 1.72 mm. Head as long as anterior three thoracic segments 1–3 combined, approximately 11 times as long as wide (Figure 30A).

Antennule (Figure 30B). Seven-segmented. First segment with one seta on inner margin, with two simple dorsal setae and with one dorsal, one ventromedial and two lateral plumose setae. Second segment with one group of four plumose setae and with four simple setae on inner margin. Third segment with three lateral setae including one plumose seta and three setae on inner margin. Inner flagellum of third segment with three simple setae. Fourth segment with one stub seta and one plumose seta on dorsal margin, and with two stub setae and two plumose setae on outer distal apophysis. Fifth segment with three setae on inner margin and one simple seta and one aesthetasc. Sixth segment with four setae on inner margin and with dorsal group of two aesthetascs, one simple seta and one additional aesthetasc lateral to simple seta. Middle part of aesthetascs barely reaching seventh segment. Seventh segment with three subterminal aesthetascs and four simple setae.

Antenna (Figure 30C). Five-segmented, as long as antennular segments 1–4 combined. Fourth segment shorter than fifth segment. Setal formula: 0+0/0+0/1+1/1+1/3(1). Plumose seta of distal segment shorter than longest simple seta.

Labrum (Figure 30D). Flat with 10 median teeth of more or less similar size flanked by two (left) or three (right) smaller teeth on each side. Ventral surface with numerous combs of ctenidia and four teats.

Mandible (Figure 30E). Incisor process of five teeth. Tooth of ventral edge triangular. Spine row consisting of eight spines. Palp of one segment, with one apical seta.

Maxillule (Figure 30F). Two-segmented. Proximal segment with four setae on inner margin. Distal segment with two terminal spines, with five spines with denticles on inner edge, and with three simple setae on outer margin. Proximal spine on inner edge tiny.

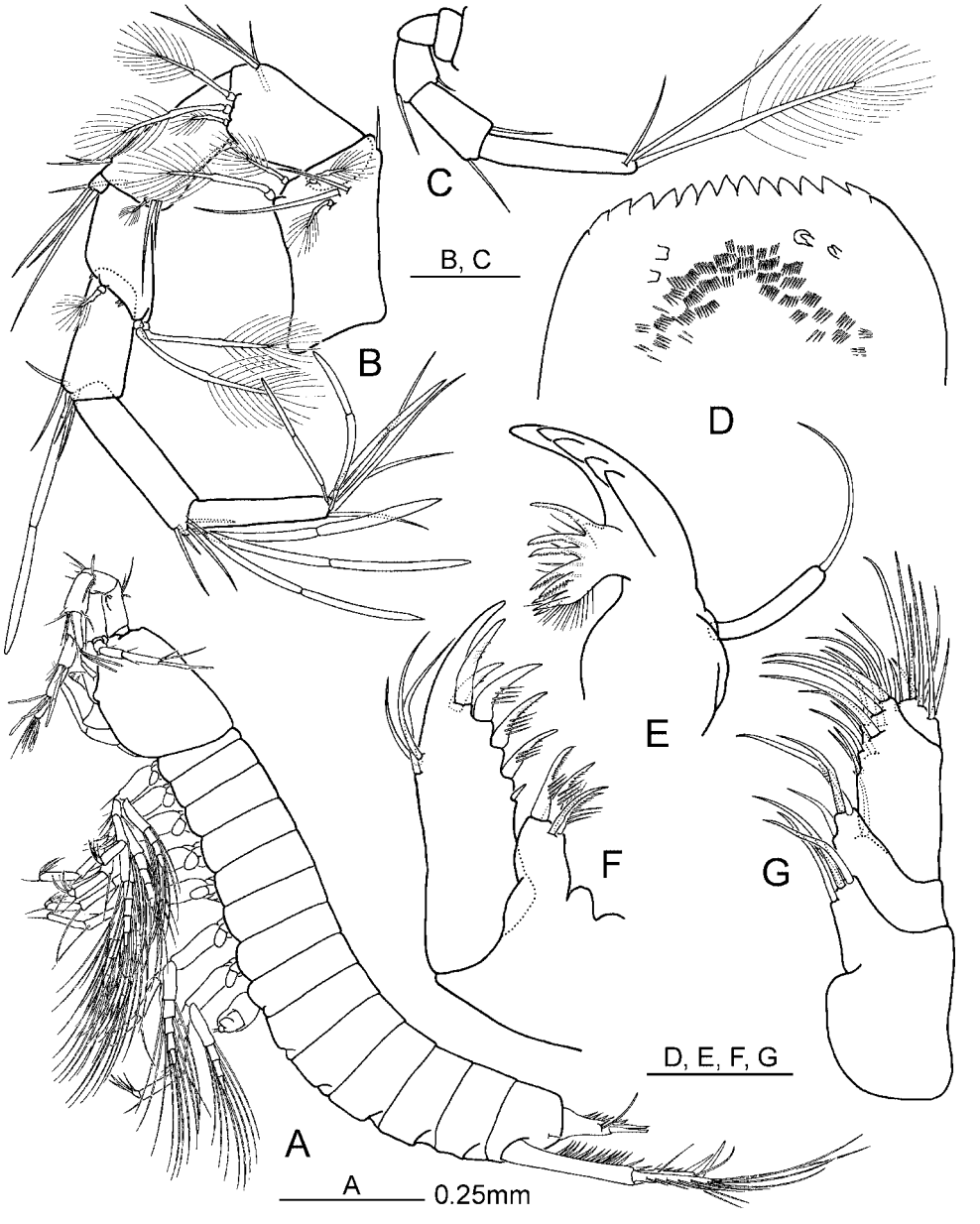

Figure 30. *Brevisomabathynella leijsi* sp. nov. (♂, holotype): (A) general habitus; (B) left antennule (dorsolateral); (C) left antenna (dorsal); (D) labrum (ventral); (E) right mandible (dorsal); (F) left maxillule (dorsal); (G) left maxilla (dorsal). Scale bars 0.05 mm (unless otherwise specified).

*Maxilla (*Figure 30G). Four-segmented, setal formula 4-5-14-8.

Thoracopods I–VII (Figures 32A–D, 33A–C). Thoracopods I–IV increasing in size posteriorly. Thoracopods IV–VII similar in size. Thoracopods II–VII each bearing

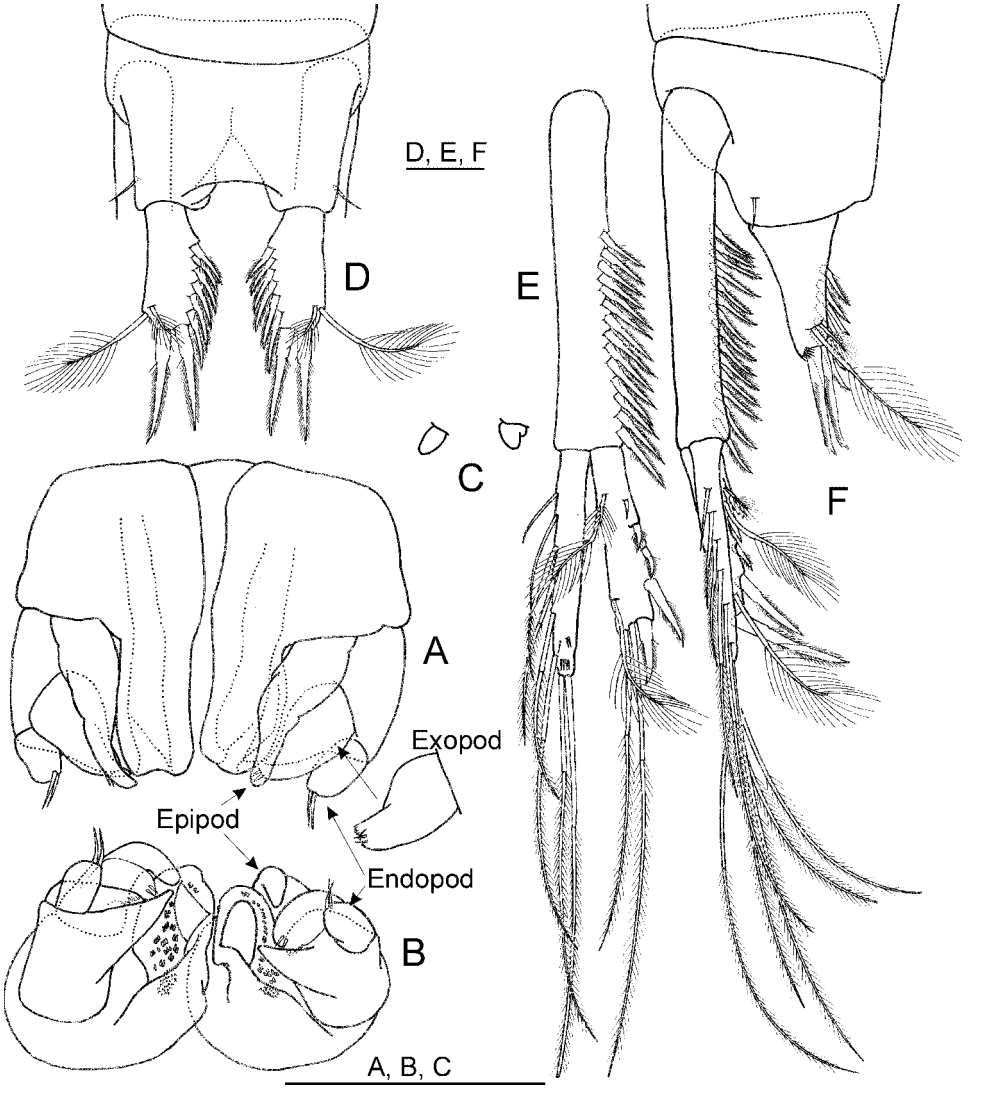

Figure 31. *Brevisomabathynella leijsi* sp. nov. (♂, holotype; ♀, allotype): (A) right and left thoracopods VIII ♂ (frontal); (B) right and left thoracopods VIII ♂ (ventral); (C) right and left thoracopods VIII ♀ (ventral); (D) pleotelson and furcal rami ♂ (dorsal); (E) uropod ♂ (dorsal); (F) pleotelson, furcal rami and uropod ♂ (lateral). Scale bars 0.05 mm.

one epipod on protopod. Basipod of thoracopods I–VII with one seta. Number of exopodal segments of thoracopods I–VII: 4-5-5-5-5-5-4. Endopod of thoracopods I–VII four-segmented, setal formulae:

Th. I	3+1/3+1/1+1/4(2)
Th. II–V	1+1/3+1/0+1/4(2)
Th. VI	1+1/2+1/0+1/3(1)
Th. VII	1+1/1+1/0+1/3(1)

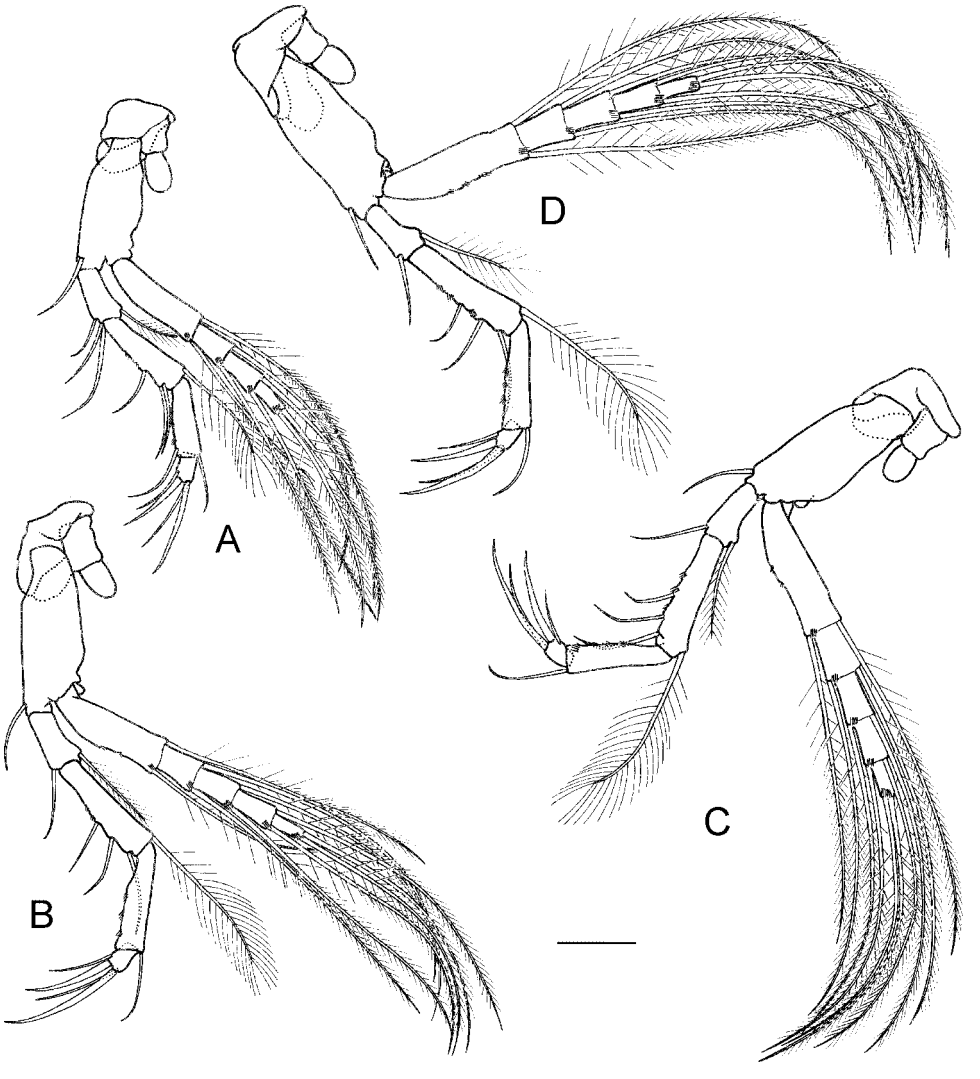

Figure 32. *Brevisomabathynella leijsi* sp. nov. (♂, holotype): (A) left thoracopod I (frontal); (B) left thoracopod II (frontal); (C) left thoracopod III (frontal); (D) left thoracopod IV (frontal). Scale bar 0.05 mm.

Thoracopod VIII (Figure 31A,B). Rectangular in frontal view, 1.7 times as long as wide. Protopod massive, with prominent penial region with terminal opening. Epipod large, triangular, distal part reaching penial region of protopod. Basipod without setae, inner margin of basipod projected. Exopod one-third size of basipod, triangular, terminally with five denticles, bearing two subterminal setae. Endopod half as long as exopod, with two terminal setae.

First pleopod. Absent.

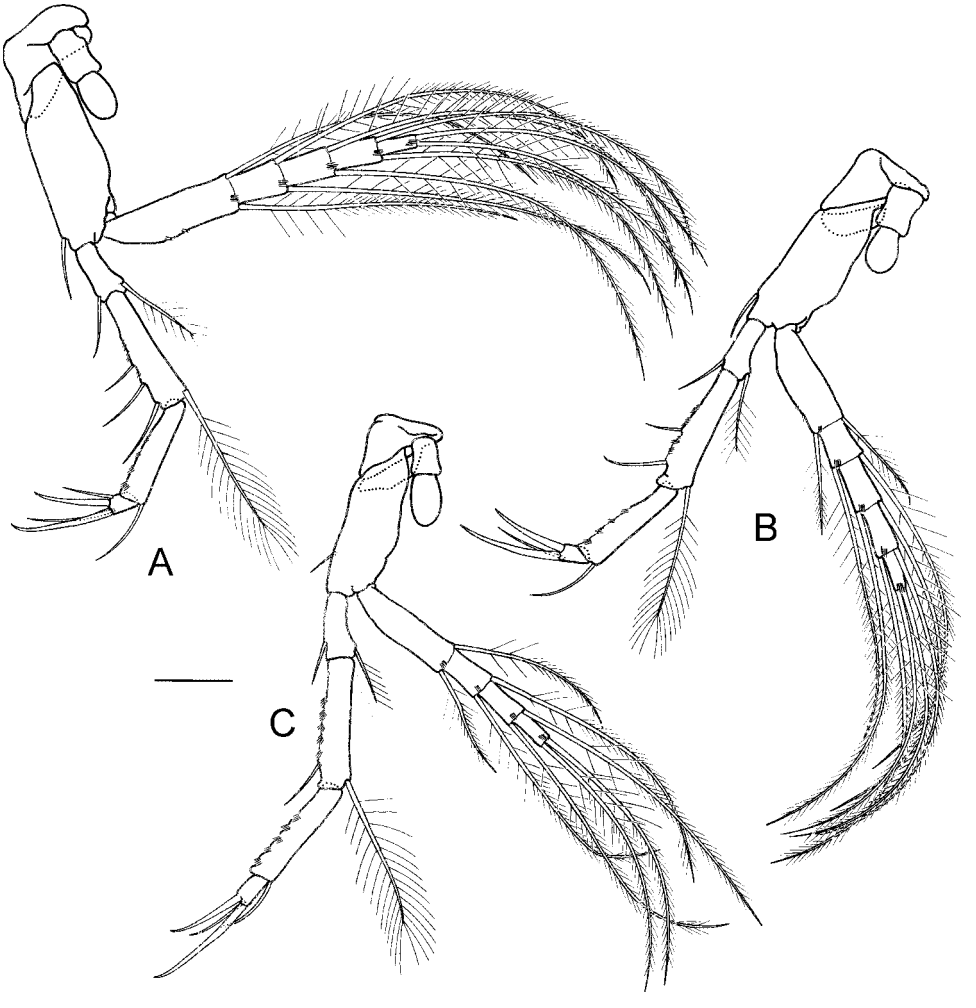

Figure 33. *Brevisomabathynella leijsi* sp. nov. (♂, holotype): (A) left thoracopod V (frontal); (B) left thoracopod VI (frontal); (C) left thoracopod VII (frontal). Scale bar 0.05 mm.

Uropod (Figure 31E,F). Fourteen spines of similar size on inner margin of sympod. Exopod 63% as long as sympod, with eight setae on outer and terminal margin, without basiventral setae. Endopod 51% as long as sympod, with two dorsal plumose setae near base, with two terminal setae and one subterminal plumose seta on outer margin, and with one terminal, one subterminal and three additional spines on inner margin. Terminal spine longer than subterminal spine. Inner-marginal spine spike-like, half as long as subterminal spine.

Pleotelson (Figure 31E,G). One seta near base of each fucal ramus on both sides. Anal operculum concave.

Furcal rami (Figure 31E,G). Twice as long as wide, with two large terminal spines, six additional spines on inner margin, and with two dorsal setae.

Description of adult female (allotype)

Body. Length 1.67 mm. Identical to male except for following characters.

Antennule. Fifth segment with four setae on inner margin.

Thoracopods IV, V. Setal formulae of endopods:

Th. IV 1+1/2+1/0+1/4(2)
Th. V 1+1/2+1/0+1/4(2)

Thoracopod VIII (Figure 31C). Conical, half as long as endopod of male thoracopod VIII.

Intraspecific variation

Range of body length of paratypes: 1.31–1.70 mm. Variation in number of setae, spines or segments of extremities as listed in Table 7.

Etymology

The specific name refers to one of the collector (Dr. R. Leijs: Adelaide, Australia).

***Brevisomabathynella hahni* sp. nov.**
(Figures 34–37)

Material examined

Holotype (adult female), allotype (adult male), paratypes (seven juveniles). Holotype: dissected on five slides (WAM C 40294). Allotype: dissected on five slides (WAM C 40295). Paratype: seven juveniles as a whole specimen on one slide (WAM C 40296).

Type locality

Australia, Western Australia, Pilbara, Millstream aquifer, piezometer 15B (21°44′35″ S, 117°14′30″ E), BES 3982, 18 October 1996, leg. W.F. Humphreys.

Description of adult female (holotype)

Body. Length 1.35 mm. Head as long as anterior three thoracic segments 1–3 combined, approximately 10 times as long as wide (Figure 34).

Antennule (Figure 35A). Seven-segmented. First segment with one seta on inner margin, with two simple dorsal setae and with one dorsal, one ventromedial and one lateral plumose seta. Second segment with one group of four plumose setae and with three simple setae on inner margin. Third segment with two lateral setae including one plumose seta and two setae on inner margin. Inner flagellum of third segment

Table 7. Intraspecific variation of *Brevisomabathynella leijsi* sp. nov. (data acquired from the six dissected specimens).

	Holotype (♂)	Allotype (♀)	Paratype 1 (♂)	Paratype 2 (♂)	Paratype 3 (♀)	Paratype 4 (♀)
Body length (mm)	1.72	1.67	1.70	1.65	1.60	1.59
Antennule (segments)						
Second segment: no. setae on inner distal margin	3	3	3	4	3	3
Fifth segment: no. setae on inner distal margin	3	4	3	4	3	3
No. of spines of spine row of mandible	8	8	8	7	7	8
Setal formula of maxilla	4-5-14-8	4-5-14-8	4-5-14-8	4-5-14-8	3-5-14-8	3-5-14-8
Thoracopods I–VII						
Setal formula of Th. III	1+1/3+1/0+1/4(2)	1+1/3+1/0+1/4(2)	1+1/3+1/0+1/4(2)	1+1/3+1/0+1/4(2)	1+1/2+1/0+1/4(2)	1+1/3+1/0+1/4(2)
Setal formula of Th. IV	1+1/3+1/0+1/4(2)	1+1/2+1/0+1/4(2)	1+1/3+1/0+1/4(2)	1+1/2+1/0+1/4(2)	1+1/2+1/0+1/4(2)	1+1/3+1/0+1/4(2)
Setal formula of Th. V	1+1/3+1/0+1/4(2)	1+1/2+1/0+1/4(2)	1+1/3+1/0+1/4(2)	1+1/2+1/0+1/4(2)	1+1/2+1/0+1/4(2)	1+1/3+1/0+1/4(2)
Setal formula of Th. VI	1+1/2+1/0+1/3(1)	1+1/2+1/0+1/3(1)	1+1/2+1/0+1/3(1)	1+1/2+1/0+1/3(1)	1+1/1+1/0+1/3(1)	1+1/2+1/0+1/4(2)
Uropod						
No. of spines on sympod	14	14	13	11	14	13
No. of setae on exopod	8	8	7	7	7	7
Furcal rami						
No. of spines on inner margin	6	6	5	7	5	7

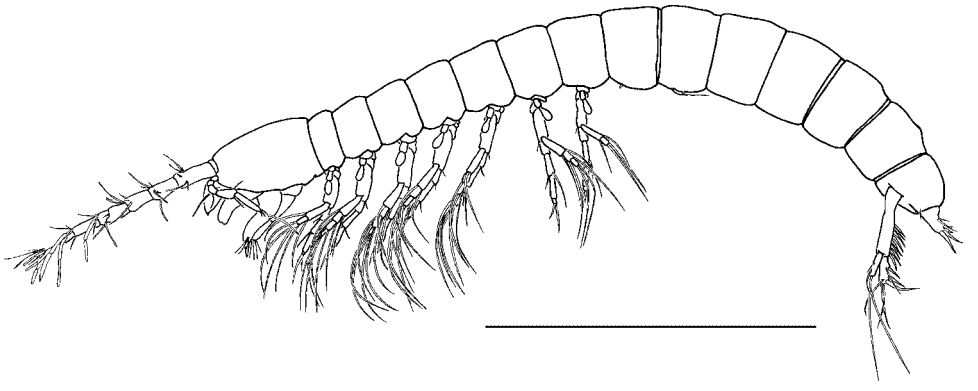

Figure 34. General habitus of *Brevisomabathynella hahni* sp. nov. (♀, holotype). Scale bar 0.5 mm.

with three simple setae. Fourth segment with one stub seta and one plumose seta on dorsal margin, and with two stub setae and two plumose setae on outer distal apophysis. Fifth segment with two simple setae on inner margin, and with one aesthetasc and one simple seta dorsally. Sixth segment with two setae on inner margin and with two aesthetascs and one seta dorsally. Middle part of aesthetascs barely reaching seventh segment. Seventh segment with three subterminal aesthetascs and four simple setae.

Antenna (Figure 35B). Five-segmented, as long as antennular segments 1–3 combined. Fourth segment slightly shorter than fifth segment. Setal formula: 0+0/0+0/1+0/1+1/4(1). Three simple setae on distal segment extremely short, at most as long as one-seventh of plumose seta.

Labrum (Figure 35C). Flat, with eight teeth of more or less similar size flanked by two teeth decreasing in size laterally on each side. Ventral surface with two pair of teats and seven combs of ctenidia.

Mandible (Figure 35D). Incisor process of four teeth. Tooth of ventral edge triangular. Spine row consisting of five spines. Palp of one segment, with one apical seta.

Maxillule (Figure 35E). Two-segmented. Proximal segment with four setae on inner margin. Distal segment with two terminal spines, with three spines with denticles and with three simple setae of different size on outer margin.

Maxilla (Figure 35F). Four-segmented, setal formula 3-3-8-7.

Thoracopods I–VII (Figures 35M, 36A–C, 37A–C). Thoracopods I–IV increasing in size posteriorly. Thoracopods IV–VI similar in size. Thoracopod VII as long as thoracopod I. Thoracopods I–VII each bearing one epipod on protopod. Basipod of

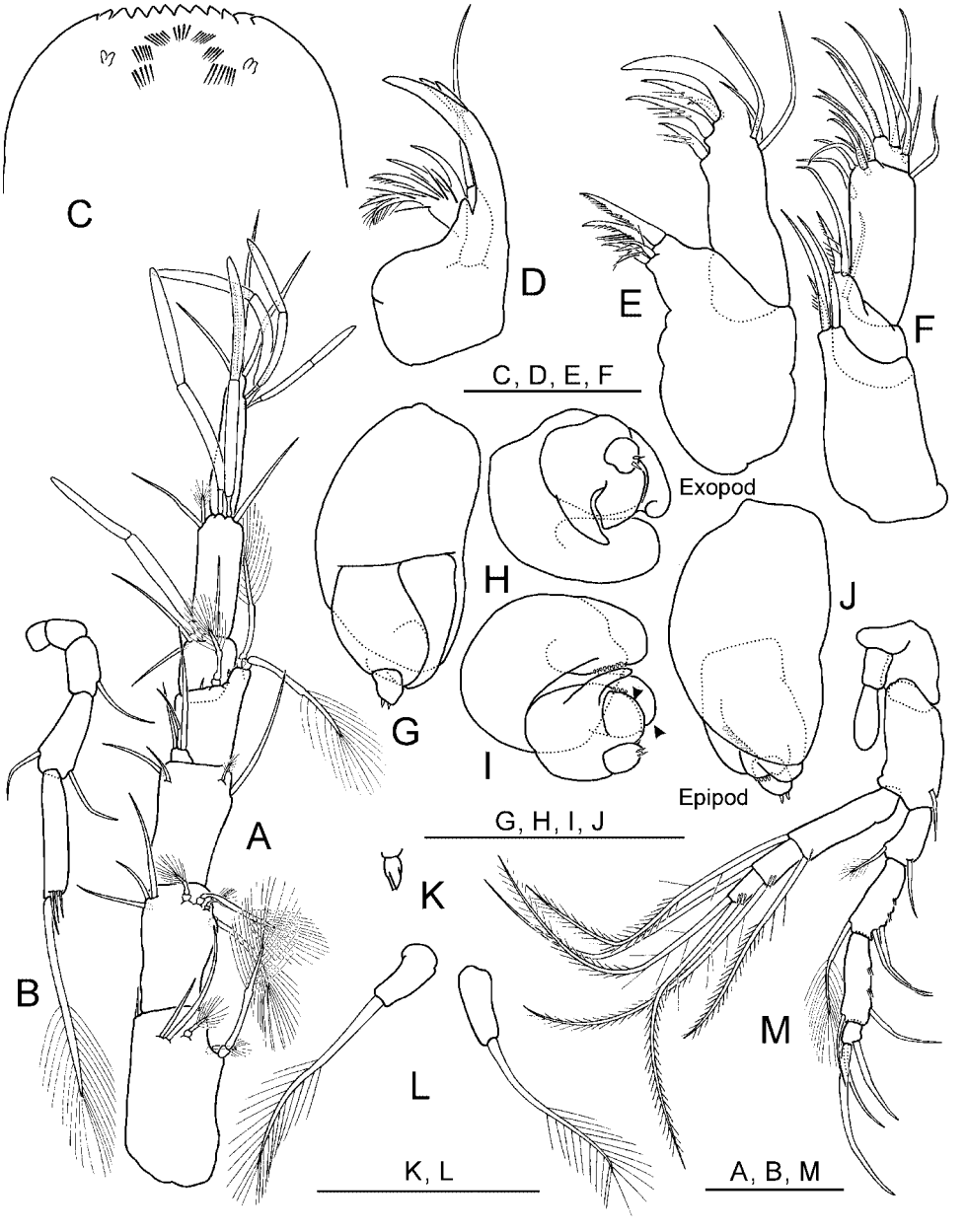

Figure 35. *Brevisomabathynella hahni* sp. nov. (♀, holotype; ♂, allotype): (A) right antennule ♀ (dorsal); (B) right antenna ♀ (dorsal); (C) labrum ♀ (ventral); (D) left mandible ♀ (ventral); (E) right maxillule ♀ (dorsal); (F) right maxilla ♀ (dorsal); (G) right thoracopod VIII ♂ (outer lateral); (H) right thoracopod VIII ♂ (ventral); (I) left thoracopod VIII ♂ (ventral); (J) left thoracopod VIII ♂ (posterior); (K) right thoracopod VIII ♀ (ventral); (L) pleopod I ♀ (ventral); (M) right thoracopod I ♀ (frontal). Scale bars 0.05 mm.

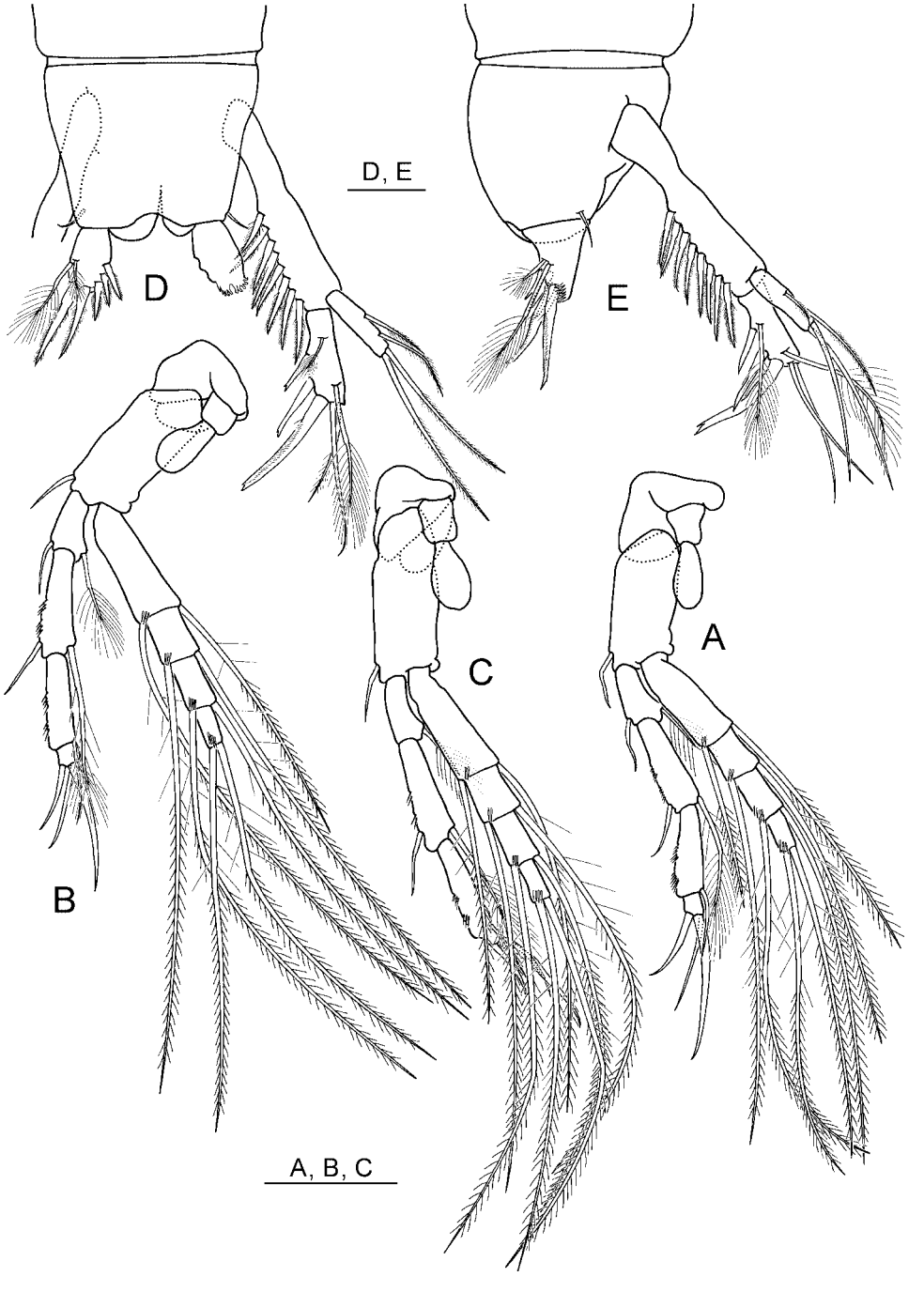

Figure 36. *Brevisomabathynella hahni* sp. nov. (♀, holotype): (A) left thoracopod II (frontal); (B) left thoracopod III (frontal); (C) left thoracopod V (frontal); (D) pleotelson, furcal rami and uropod (dorsal); (E) pleotelson, furcal rami and uropod (lateral). Scale bars 0.05 mm.

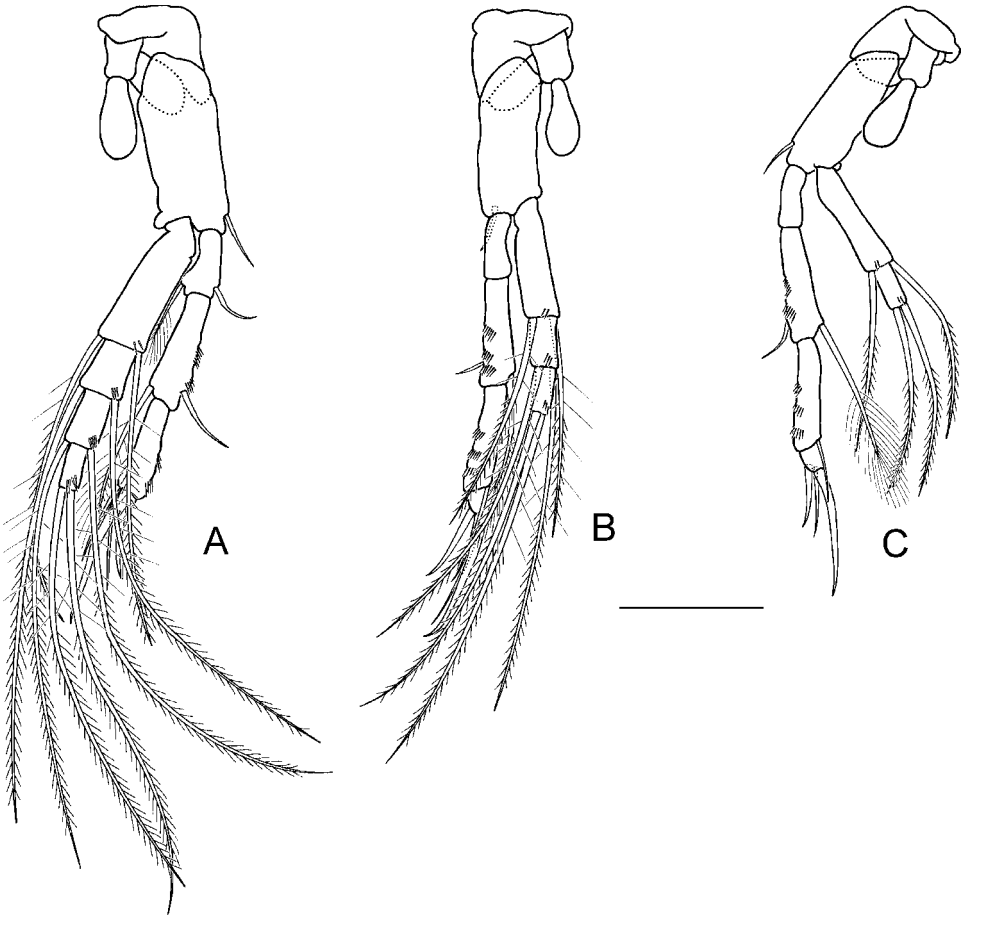

Figure 37. *Brevisomabathynella hahni* sp. nov. (♀, holotype): (A) right thoracopod IV (frontal); (B) left thoracopod VI (frontal); (C) left thoracopod VII (frontal). Scale bar 0.05 mm.

thoracopods I–VII with one seta. Number of exopodal segments of thoracopods I–VII: 3-4-4-4-4-3-2. Endopod of thoracopods I–VII four-segmented, setal formulae:

Th. I	1+1/2+1/1+1/3(1)
Th. II–IV	1+1/1+1/0+1/3(1)
Th. V	0+1/1+1/0+1/3(1)
Th. VI, VII	0+0/1+1/0+1/3(1)

Thoracopod VIII (Figure 35K). Conical, as long as endopod of male thoracopod VIII, with two terminal teeth.

First pleopod (Figure 35L). First pleopod in form of two stubs separated from each other. Each stub bearing one terminal seta.

Uropod (Figure 36D,E). Eight spines of similar size on inner margin of sympod. Exopod 35% as long as sympod, with four setae on outer and terminal margin, without

basiventral setae. Endopod 42% as long as sympod, with one dorsal plumose seta near base, with two terminal setae and one subterminal plumose seta on outer margin, and with one terminal, one subterminal and one additional spine on inner margin. Terminal spine twice as long as subterminal spine. Inner-marginal spine spike-like, two-thirds as long as subterminal spine.

Pleotelson (Figure 36D,E). One seta near base of each furcal ramus on both sides. Anal operculum concave.

Furcal rami (Figure 36D,E). 1.3 times as long as wide, with two large terminal spines, and three smaller spines on inner margin, and with two dorsal setae.

Description of adult male (allotype)

Body. Length 1.31 mm. Identical to female except for following characters.

Thoracopod VIII (Figure 35G–J). More or less oval in lateral view, twice as long as wide. Protopod massive, with prominent penial region. Epipod large, triangular, distal part barely reaching terminal end of penial region. Basipod without setae, inner margin of basipod drawn out into projection. Exopod one-third size of basipod, triangular, with four to five terminal denticles, but without setae. Endopod half as long as exopod, with two terminal setae.

Uropod. Sympod with seven spines. Exopod with three setae.

Etymology

The specific name refers to Dr H.J. Hahn (Landau, Germany) who provided material for our studies.

***Brevisomabathynella pilbaraensis* sp. nov.**

(Figures 38–40)

Material examined

Holotype (adult male), allotype (adult female), paratype (adult male). Holotype: dissected on five slides (WAM C 40297). Allotype: dissected on five slides, same data as for holotype except Bore near W126 (23°13′ S, 119°53′ E), BES 3574 (WAM C 40298). Paratype: as a whole specimen in a slide, same data as for holotype except Bore near W120 (23°13′ S, 119°53′ E), BES 3527, (WAM C 40299).

Type locality

Australia, Western Australia, Pilbara, Ethel Creek, Bore W230 (23°13′ S, 119°54′ E), BES 3468, 11 November 1998, leg. S.M. Eberhard.

Description of adult male (holotype)

Body. Length 1.32 mm. Head as long as anterior three thoracic segments 1–3 combined, approximately 11 times as long as wide (Figure 38A).

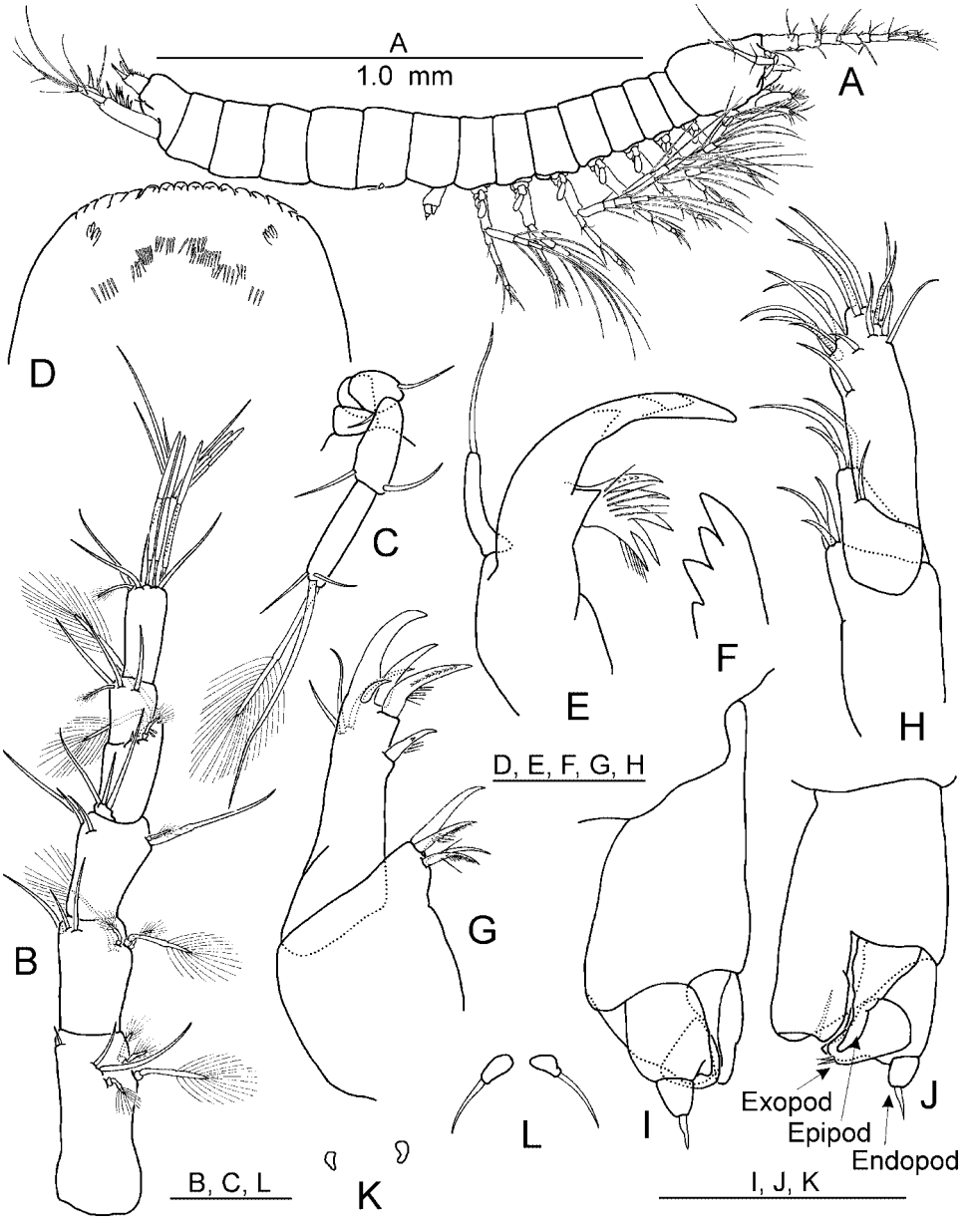

Figure 38. *Brevisomabathynella pilbaraensis* sp. nov. (♂, holotype; ♀, allotype): (A) general habitus ♂; (B) right antennule ♂ (dorsal); (C) right antenna ♂ (dorsal); (D) labrum ♂ (ventral); (E) right mandible ♂ (ventral); (F) incisor process (lateral); (G) left maxillule ♂ (ventral); (H) left maxilla ♂ (dorsal); (I) left thoracopod VIII ♂ (inner lateral); (J) left thoracopod VIII ♂ (frontal); (K) right and left thoracopods VIII ♀ (ventral); (L) pleopod I ♂ (ventral). Scale bars 0.05 mm (unless otherwise specified).

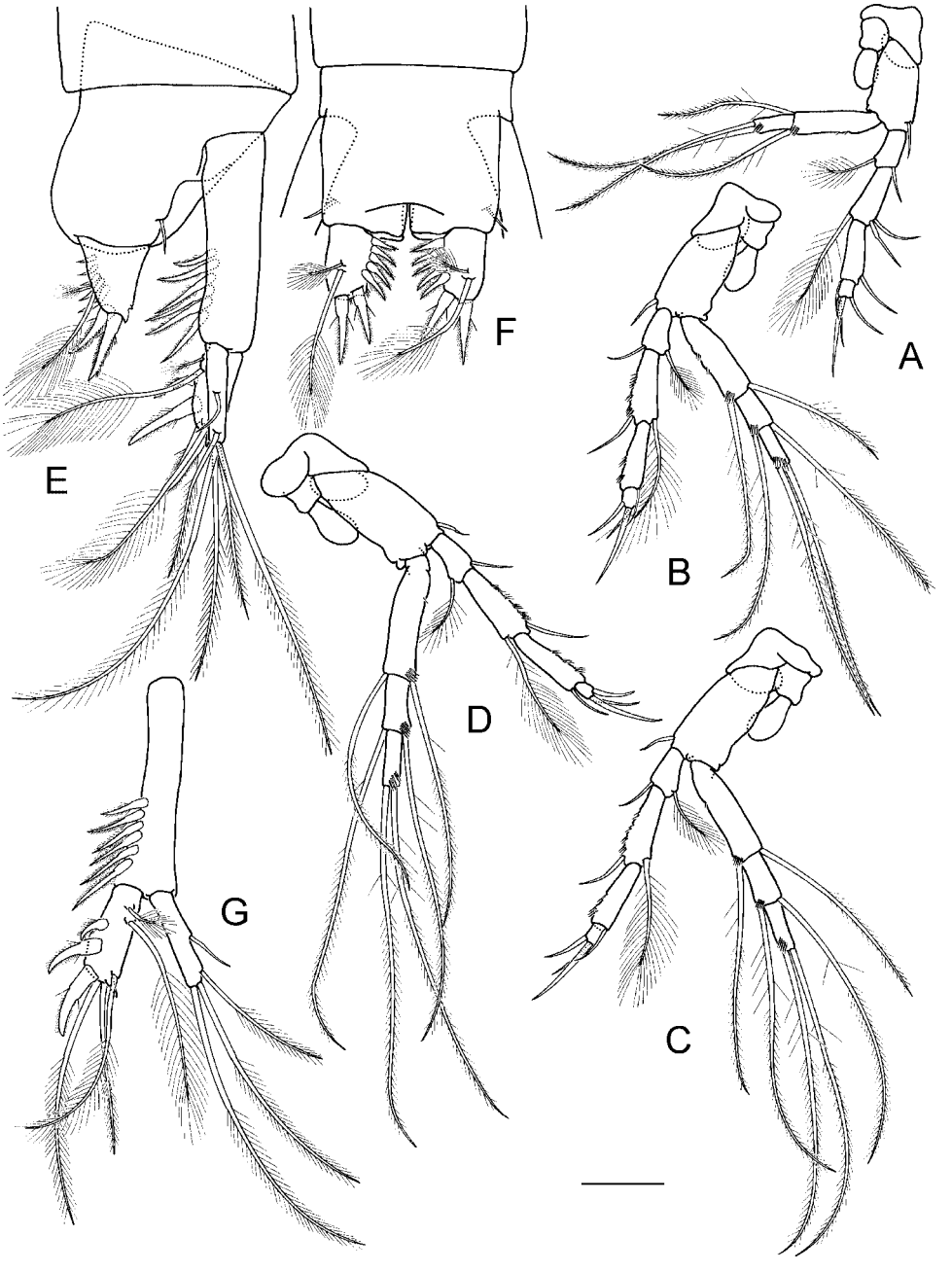

Figure 39. *Brevisomabathynella pilbaraensis* sp. nov. (♂, holotype): (A) right thoracopod I (frontal); (B) left thoracopod II (frontal); (C) left thoracopod III (frontal); (D) right thoracopod IV (frontal); (E) pleotelson, furcal rami and uropod (lateral); (F) pleotelson and furcal rami (dorsal); (G) uropod (dorsal). Scale bar 0.05 mm.

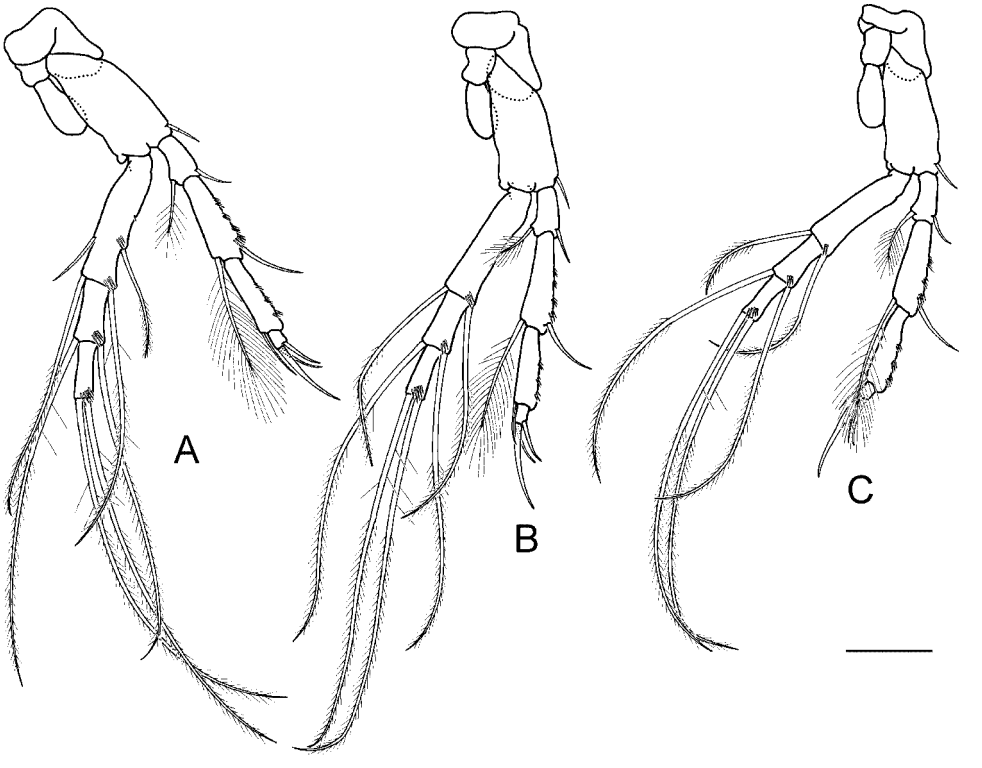

Figure 40. *Brevisomabathynella pilbaraensis* sp. nov. (♂, holotype): (A) left thoracopod V (frontal); (B) left thoracopod VI (frontal); (C) left thoracopod VII (frontal). Scale bar 0.05 mm.

Antennule (Figure 38B). Seven-segmented. First segment with one seta on inner margin, with two simple dorsal setae and with one dorsal, one ventromedial and two lateral plumose setae. Second segment with one group of four plumose setae and with three simple setae on inner margin. Third segment with two lateral setae including one plumose seta and three setae on inner margin. Inner flagellum of third segment with three simple setae. Fourth segment with one stub seta and one plumose seta on dorsal margin, and with two stub setae and two plumose setae on outer distal apophysis. Fifth segment with three simple setae and one plumose seta. Sixth segment with four setae on inner margin and with dorsal group of two aesthetascs, one simple seta and one additional aesthetasc lateral to simple seta. Middle part of aesthetascs barely reaching seventh segment. Seventh segment with three subterminal aesthetascs and four simple setae.

Antenna (Figure 38C). Five-segmented, as long as antennular segments 1–3 combined. Fourth segment slightly shorter than fifth segment and slightly thicker. Setal formula: 0+0/0+0/1+1/1+1/4(1). Plumose seta of distal segment shorter than longest simple seta.

Labrum (Figure 38D). Flat, with eight teeth of more or less similar size flanked by five teeth decreasing in size laterally on each side. Ventral surface with four pair of teats and numerous combs of ctenidia.

Mandible (Figure 38E,F). Incisor process of four teeth. Tooth of ventral edge triangular. Spine row consisting of five spines. Palp of one segment, with one apical seta.

Maxillule (Figure 38G). Two-segmented. Proximal segment with four setae on inner margin. Distal segment with two terminal spines, with three spines with denticles and with three simple setae of different size on outer margin.

Maxilla (Figure 38H). Four-segmented, setal formula 3-4-7-8.

Thoracopods I–VII (Figures 39A–D, 40A–C). Thoracopods I–IV increasing in size posteriorly. Thoracopods IV–VII similar in size. Thoracopods I–VII each bearing one epipod on protopod. Basipod of thoracopods I–VII with one seta. Number of exopodal segments of thoracopods I–VII: 2-3-3-3-3-3-3. Endopod of thoracopods I–VII four-segmented, setal formulae:

Th. I	1+1/2+1/1+1/3(1)
Th. II–VII	1+1/1+1/0+1/3(1)

Thoracopod VIII (Figure 38I,J). Rectangular in frontal view, 1.5 times as long as wide. Protopod massive, with prominent penial region. Epipod large, triangular, distal part barely reaching terminal end of penial region. Basipod without setae, inner margin of basipod drawn out into projection. Exopod one-third size of basipod, triangular, with two subterminal setae. Endopod one-half size of exopod, with one terminal seta.

First pleopod (Figure 38L). Small, in form of two small stubs separated from each other. Each stub bearing one terminal seta.

Uropod (Figure 39E,G). Six spines of similar size on inner margin of sympod. Exopod as long as endopod, with four setae on outer and terminal margin, without basiventral setae. Endopod 46% as long as sympod, with two dorsal plumose setae near base, with two terminal setae and one subterminal plumose seta on outer margin, and with one terminal, one subterminal and one additional spine on inner margin. Terminal spine somewhat longer than subterminal spine. Inner-marginal spine spike-like, two-thirds as long as subterminal spine.

Pleotelson (Figure 39E,F). One seta near base of each furcal ramus on both sides. Anal operculum convex.

Furcal rami (Figure 39E,F). 1.2 times as long as wide, with two large terminal spines, and five smaller spines on inner margin, and with two dorsal setae.

Description of adult female (allotype)

Body. Length 1.35 mm. Identical to male except for following characters.

Thoracopod VIII (Figure 38K). Conical, half as long as endopod of male thoracopod VIII.

Uropod. Sympod with five spines.

Intraspecific variation

Body length of paratype: 1.31 mm. Paratype does not differ from holotype.

Etymology

The specific name refers to Pilbara, Australia.

Discussion

Taxonomic affinity

The 10 new species show many generic characters of *Billibathynella* Cho, 2005. These include (1) the body form in general, (2) seven-segmented antennules, (3) the mandible with incisor process of more than five spines and with palp being twice as long as wide, (4) the four-segmented maxilla, (5) the multi-segmented exopod of thoracopods I–VII, (6) the rectangular male thoracopod VIII with large triangular epipod and without basipodal setae, (7) the uropod with numerous spines on sympod, (8) the flat to slightly concave anal operculum, and (9) the elongated furcal rami with two large terminal spines and numerous spines on inner margin. But, assigning these species to *Billibathynella* is precluded by two characters: the five-segmented antenna and the absence of a basiventral seta on the uropodal exopod.

As mentioned by Schminke (1973), the basiventral seta of the uropodal exopod is not common within Parabathynellidae, but could characterize some genera such as *Allobathynella* Morimoto and Miura, 1957, *Iberobathynella* Schminke, 1973 and *Kimberleybathynella* Cho et al., 2005, as it is present in all the species of these three genera. According to Hong and Cho (2009) this seta is lacking in only two out of 10 species of *Atopobathynella* Schminke, 1973 and one of four species of *Billibathynella.* The presence of the basiventral seta is typical of the two genera. The number of antennal segments within a genus is also constant, a character which, together with the mouthparts and the male thoracopod VIII, is important in distinguishing the parabathynellid genera (Schminke 1973). There are two exceptions. The first is *Notobathynella* Schminke, 1973, a genus of six species, one of which (*Notobathynella remota* Schminke, 1973) has six antennal segments versus five in the remaining species. The other is *Chilibathynella* Schminke, 1973, which includes three species one of which (*Chilibathynella kotumsarensis* Ranga Reddy, 2006) has six antennal segments versus five in the two remaining species. In these exceptional cases, however, the difference between the number of antennal segments is not two as between the 10 new species and *Billibathynella*, but only one. In addition, the two species with six antennal segments differ from their congeners so slightly that one would barely erect a genus (Drewes and Schminke 2007; Ranga Reddy 2006).

The five-segmented antenna and the absence of a basiventral seta on the uropodal exopod would be a weak argument for separating the 10 new species from *Billibathynella*. However, our proposition is supported by the molecular–phylogenenetic analysis of Guzik et al. (2008), which considered 13 undescribed species and four known species sampled from diverse calcrete aquifers distributed in the Yilgarn region of Western Australia. According to this analysis using molecular sequence data of the mitochondrial DNA cytochrome *c* oxidase I gene, the 17 species are separated into three distinct monophyletic clades. The first clade included one undescribed species and three known species of *Atopobathynella* Schminke, 1973. The

second clade included two undescribed species, which could be assigned to *Billibathynella*, as they display seven-segmented antennae and a basiventral seta on uropodal exopod. The third clade, which had a sister relationship to the second clade, included 10 undescribed species and one known species of *Brevisomabathynella* Cho, 2006 displaying five-segmented antenna, but lacking a basiventral seta on the uropodal exopod.

At this juncture, it should be explained why the 10 new species, especially *B. uramurdahensis* with the fat-bellied body form and heterogenous spines on the uropodal sympod, are assigned to *Brevisomabathynella*, which as yet includes two known species (*B. cooperi* Cho et al., 2006 and *B. cunyuensis* Cho et al., 2006) having a series of unusual characters, such as the foreshortened body form, gargantuan labrum with a high number (>30) of narrow teeth, the incisor process with four main and three tiny additional teeth and the two disto-inner spines of the distal endite of the maxillule being longer than the terminal spines (Cho et al., 2006). All of these characters are unique within Parabathynellidae, probably providing sufficient arguments for excluding the 10 new species lacking them from *Brevisomabathynella*. However, six of the 10 new species herein described, *B. magna*, *B. uramurdahensis*, *B. jundeeensis*, *B. parooensis*, *B. eberhardi* and *B. clayi*, are considered by Guzik et al. (2008) and designated as sp. 1, sp. 2, sp. 3, sp. 4, sp. 5 and sp. 9, respectively, while they are temporarily bundled into "genus A". According to Guzik's cladogram, *B. cooperi* is incorporated into "genus A" and has a sister relationship to *B. jundeeensis*, rendering the remaining species and "genus A" polyphyletic.

In the molecular analysis of Guzik et al. (2008), on the other hand, *B. cunyuensis* and four (*B. changjini*, *B. leiji*, *B. hahni* and *B. pilbaraensis*) of the 10 new species are not considered. In addition, a phylogenetic analysis based on a single mitochondrial marker reflects the history of the species divergence only incompletely (Avise 1989; Moore 1995). Even in morphological context, however, a new genus (for example the "genus A") for the 10 new species would be, at most, a paraphyletic assemblage, as this putative genus could not be defined by its own synapomorphy. We stress that the 10 new species and two currently known species of *Brevisomabathynella* have in common the five-segmented antenna and the absence of a basiventral seta on the uropodal exopod. Both characters occur otherwise in *Notobathynella*. But this genus differs from *Brevisomabathynella* in having a basipodal seta on the male thoracopod VIII and heterogenous spines of uropodal sympod (see Hong and Cho 2009). We therefore assign the 10 new species to *Brevisomabathynella*, while regarding *B. cooperi* and *B. cunyuensis* as derived members of the genus. Accordingly, the generic diagnosis is amended above.

Comparison of visible external structure

The 10 new species of *Brevisomabathynella* Cho, Park and Ranga Reddy, 2006, *B. magna* sp. nov., *B. changjini* sp. nov., *B. clayi* sp. nov., *B. uramurdahensis* sp. nov., *B. jundeeensis* sp. nov., *B. parooensis* sp. nov., *B. eberhardi* sp. nov., *B. leijsi* sp. nov., *B. hahni* sp. nov. and *B. pilbaraensis* sp. nov. can be recognized by several characters listed in Table 8. They differ also clearly from two known species of the genus (*B. cooperi* and *B. cunyuensis*) in lacking a series of unusual characters mentioned in the foregoing section (see also Cho, Park and Ranga Reddy 2006: table 1, p.40). The body size ranges from 1.18 to 4.62 mm. Body size relates to some meristic (= countable

Table 8. Morphological differences between ten new species of the genus *Brevisomabathynella* Cho, 2006.

	1	2	3	4	5	6	7	8	9	10
Body (max.)	4.62 mm	4.24 mm	3.52 mm	3.62 mm	3.42 mm	2.01 mm	1.82 mm	1.72 mm	1.35 mm	1.35 mm
Antennule										
1. segment	4d, 2lp	4d, 2lp	5d, 1lp	4d, 2lp	3d, 2lp	2d, 2lp	3d, 2lp	2d, 2lp	2d, 1lp	2d, 2lp
2. segment	7 i	6i	4i	6i	4i or 6i	5i	5i	4i	3i	3i
3. segment	41, 6 i, 1m	3l,5i	3l, 6i	3l, 6i	3l, 6i	3l, 4i	3l, 4i	3l, 3i	3l, 2i	2l, 3i
5. segment	5i, 1d	4i, 1d	3i,1d	5i, 1d, 1a	4i 1d	2i, 1d, 2a	4i, 1d	3i, 1d, 1a	2i, 1d, 1a	3i, 1d
6. segment	4i, 2a,1d,1a	3i,2a,1d, 1a	4i,2a,1a	5i,2a,1d, 1a	4i, 2a,1d,1a	4i, 2a,1d,1a	3i,2a,1d,1a	3i,2a,1d,1a	2i, 2a, 1d	3i, 2a,1d,1a
Aesthetascs	short	short	long	short	short	short	short	short	long	long
Antenna										
Penult : distal segment	Penult > distal	Penult = distal	Penult < distal	Penult = distal	Penult < distal	Penult < distal	Penult < distal	Penult = distal	Penult < distal	Penult < distal
No. setae on third segment	1 + 1	1 + 1	1 + 2	1 + 1	1 + 1	1 + 1	1 + 1	1 + 1	1 + 0	1 + 1
No. setae on fourth segment	2 + 1	2 + 1	1 + 1	2 + 2	1 + 1	1 + 1	1 + 1	1 + 1	1 + 1	1 + 1
Distal segment										
No. setae	5	4	3	4	3	3	3	3	4	4
Plumose : simple setae	Plumose < simple	Plumose < simple	Plumose < simple	Plumose < simple	Plumose < simple	Plumose > simple	Plumose = simple	Plumose < simple	Plumose > simple	Plumose < simple
Labrum										
No. teeth on free margin	18: 8+ (5 × 2)	21: 12+ (4+5)	23: 10+ (6+7)	27: 14+ (6+7)	24: 12+ (6 × 2)	16: 8+ (4 × 2)	18: 10+ (4 × 2)	15: 10+ (2+3)	12: 8+ (2 × 2)	18: 8+ (5 × 2)

(*Continued*)

Table 8.

	1	2	3	4	5	6	7	8	9	10
Mandible										
No. teeth of incisor process	7	7	6	5	6	5	5	5	4	4
No. of spines of spine row	13	12	12	20	12	9	9	8	5	5
Maxillule										
No. spines on distal segment	7	7	7	7	7	7	7	7	5	5
Maxilla										
No. setae on first segment	8	6	4	6	5	3	3,4	4	3	3
No. setae on second segment	7	7	6	7	5	5	4	5	3	4
No. setae on third segment	18	17	14	22	11	11	11	14	8	7
No. setae on fourth segment	17	13	11	24	9	9	9	8	7	8
Thoracopods I–VII										
No. basipodal setae Th. I	2	1	1	2	1	1	1	1	1	1
No. exopodal segments										
Thoracopod I	5	7	4	9	5	5	4	4	3	2
Thoracopod II	8	8	5	11	7	6	5	5	4	3
Thoracopod III	9	9	6	12	8	6	5	5	4	3
Thoracopod IV	10	10	7	11	9	7	6	5	4	3
Thoracopod V	9,10	9, 10	7	11	9	7	6	5	4	3
Thoracopod VI	8	9	7	11	9	6	5	5	3	3
Thoracopod VII	9	9	7	11	8	6	5	4	2	3

Setation on endopod										
Thoracopod I	5+1/7+2/4 +1/4(2)	5+1/11+1/4 +1/6(4)	3+1/5+1/2 +1/4(2)	5+1/8+1/6 +1/4(2)	3+1/5+1/2 +1/4(2)	2+1/3+1/1 +1/4(2)	3+1/3+1/1 +1/4(2)	3+1/3+1/1 +1/4(2)	1+1/2+1/1 +1/3(1)	1+1/2+1/1 +1/3(1)
Thoracopod II	2+1/7 +2/4,3+ 1/4(2),5(3)	2+1/8 +1/4 +1/6(4)	2+1/4 +1/0 +1/4(2)	3+1/9 +2/5 +1/6(4)	2+1/5 +1/2 +1/4(2)	1+1/2 +2/0 +1/4(2)	1+1/2 +2/0 +1/4(2)	1+1/3 +1/0 +1/4(2)	1+1/1 +1/0 +1/3(1)	1+1/1 +1/0 +1/3(1)
Thoracopod III	2,3+1/7,6 +2/4,3+ 1/5(3),4(2)	2+1/7+1/5 +1/6(4)	2+1/3+1/0 +1/4(2)	3+1/9+2/5 +1/6(4)	2+1/5+1/2 +1/4(2)	1+1/2+2/0 +1/4(2)	1+1/3+2/0 +1/4(2)	1+1/3+1/0 +1/4(2)	1+1/1+1/0 +1/3(1)	1+1/1+1/0 +1/3(1)
Thoracopod IV	2+1/7+2/3 +1/4(2)	2+1/7+1/4 +1/6(4)	1+1/4+1/0 +1/4(2)	3+1/8+2/5 +1/6(4)	2+1/6+1/2 +1/5(3)	1+1/2+2/0 +1/4(2)	1+1/2+2/0 +1/4(2)	1+1/3+1/0 +1/4(2)	1+1/1+1/0 +1/3(1)	1+1/1+1/0 +1/3(1)
Thoracopod V	2+1/6+2/3 +1/4(2)	2+1/7+1/4 +2/6(4)	1+1/4+1/0 +1/4(2)	3+1/8+2/5 +2/6(4)	2+1/5+1/2 +1/4(2)	1+1/2+2/0 +1/4(2)	1+1/2+2/0 +1/4(2)	1+1/3+1/0 +1/4(2)	0+1/2+1/0 +1/3(1)	1+1/1+1/0 +1/3(1)
Thoracopod VI	2+1/6+2/4 +1/4(2)	2+1/8+1/4 +1/5(3)	1+1/3+1/0 +1/4(2)	2+1/8+2/5 +1/5(3)	1+1/5+1/1 +1/4(2)	1+1/2+2/0 +1/4(2)	1+1/1+2/0 +1/4(2)	1+1/2+1/0 +1/3(1)	0+0/0+1/0 +1/3(1)	1+1/1+1/0 +1/3(1)
Thoracopod VII	1+1/5+2/2 +1/5(3)	2+1/6+1/4 +1/6(4)	1+1/1+1/0 +1/4(2)	2+1/6+2/4 +1/4(2)	1+1/4+1/3 +1/4(2)	1+1/2+2/0 +1/4(2)	0+1/1+1/0 +1/4(2)	1+1/1+1/0 +1/3(1)	0+0/1+1/0 +1/3(1)	1+1/1+1/0 +1/3(1)
Male Thoracopod VIII										
Length:width	1.2:1	1.3:1	2.0:1	2.0:1	2.0:1	1.5:1	2.0:1	1.7:1	2.0:1	1.5:1
Basipod	smooth	smooth	With ctenidia	smooth	smooth	smooth	smooth	smooth	smooth	smooth
Exopod										
No. sub-terminal setae	2	2	2	3	2	2	2	2	0	2
No. terminal denticles	0	5	5	5	0	4–5	4	5	4–5	0

(*Continued*)

Table 8. (Continued).

	1	2	3	4	5	6	7	8	9	10
Endopod										
Size	Similar to exopod	2/3 of exopod	1/2 of exopod	Similar to exopod	Similar to exopod	1/2 of exopod	Similar to exopod	Similar to exopod	1/2 of exopod	1/2 of exopod
No. setae	2	2	2	3	2	2	2	2	2	1
Pleopod I	present	present	absent	present	absent	present	present	absent	present	present
No. setae	2	2	-	2	-	2	2	-	1	1
left and right pleopod I	attached closely	gapped	-	gapped	-	distanced	distanced	-	distanced	distanced
Uropod										
No. spines on sympod	20	18	16	20	15	12	10	14	8	6
Endopod:Exopod	endo<exo	endo<exo	endo>exo	endo<exo	endo<exo	endo<exo	endo=exo	endo<exo	endo>exo	endo=exo
Endopod										
No. spines	5	4	5	4	5	5	4	5	3	3
Length of inner spines	long	long	long	long	long	short	short	long	long	long
Exopod.										
No. setae	11	12	6	10	11	8	6	8	4	4
No. spines on furcal rami	20	15	13, 12	11, 12	14	8	9, 10	8	5	7

Notes: 1: *B. magna* sp. nov.; 2: *B. changjini* sp. nov.; 3: *B. clayi* sp. nov.; 4. *B. uramurdahensis* sp. nov.; 5: *B. jundeeensis* sp. nov.; 6: *B. parooensis* sp. nov.; 7: *B. eberhardi* sp. nov.; 8: *B. leijsi* sp. nov.; 9. *B. hahni* sp. nov.; 10: *B. pilbaraensis* sp. nov. d: dorsal setae; lp: lateral plumose setae; i: setae on inner margin; m: median seta; a: aesthetasc.

or quantitative) characters that are of little phylogenetic use because they simply increase in numbers with body size. On the other hand, there are characters distributed among species irrespective of body size, which provide constitutive characters for species and are of phylogenetic use for supraspecific taxa as well. In this section, we treat only the differences between 10 new species because the uniqueness of *B. cooperi* and *B. cunyuensis* is discussed in detail elsewhere (Cho, Park and Ranga Reddy 2006).

Body size and meristic measurements

It is not the intention here to provide a comprehensive treatment of the relationship between meristic measurements and body size of parabathynellids, rather to establish that within *Brevisomabathynella* many parameters routinely described and enumerated in parabathynellids are often strongly correlated with the size of the species. It is not known how this relationship develops during ontogeny nor whether this is a general circumstance within parabathynellids. Clearly, however, this has implications for the interpretation of meristic characters used for species recognition and for phylogenetic interpretation, and the relationships warrant full treatment within Bathynellacea.

Many of the meristic characters in the 10 species of *Brevisomabathynella* examined here, taken from Table 8, have a positive relationship with body length (proxy for body size), a relationship established by regressing the meristic character against body length. Twenty-two of 26 comparisons were significant at $p < 0.05$ in individual tests. To establish the most conservative comparison we applied a Bonferroni correction for 26 multiple comparisons setting $\beta = 0.0019$ for $\alpha = 0.05$. The total number of setae on the antennule increases with body length on segment 3 ($r^2 = 0.830$, $p < 0.05$). Similar associations are seen on the mandible with the number of teeth on the incisor process ($r^2 = 0.842$, $p < 0.05$) and the number of setae on segments 1 and 2 on the maxilla ($r^2 = 0.801$, $p < 0.05$ and $r^2 = 0.799$, $p < 0.05$, respectively). The number of exopodal segments on thoracopods IV ($r^2 = 0.795$, $p < 0.05$) and VII ($r^2 = 0.783$, $p < 0.05$) are similarly positively related to body length, as are the total number of setae on the endopods of each of thoracopods I and II ($r^2 = 0.769$, $p < 0.05$ and $r^2 = 0.719$, $p < 0.05$, respectively).

The antennule

With exceptions of the fourth and seventh segments, the antennule is rich in variation, which is generally correlated with body size, undoubtedly with a few exceptions. In *B. clayi* with a body size of 3.52 mm, for example, the first segment displays the largest number of dorsal setae (five), but only one lateral plumose seta, as does *B. hahni*, which has a much smaller body size of 1.35 mm (for further exceptions see Table 8). Remarkable characters, which are apparently independent of body size, are:

(1) An aesthetasc of fifth segment is present in *B. uramurdahensis*, *B. parooensis*, *B. leijsi* and *B. hahni* but is absent in *B. magna*, *B. changjini*, *B. clayi*, *B. jundeeensis*, *B. eberhardi* and *B. pilbaraensis*.
(2) The aesthetasc of the sixth segment located closely outwards of the dorsal simple seta is absent only in *B. hahni*, while the dorsal simple seta is absent only in *B. clayi.*

(3) The aesthetascs of the sixth segment are long to an extent that their middle part reaches barely the seventh segment in *B. leijsi*, *B. hahni* and *B. pilbaraensis*, but not so long in the seven remaining species.
(4) A medial seta located on the outer margin of third antennular segment is present only in *B. magna*.

The antenna

The antenna of the 10 new species belongs to the second type of five-segmented antenna (*sensu* Drewes and Schminke 2007), as the first and second segments have no setae. According to Drewes and Schminke (2007), the penultimate and distal segments of the antenna in this type are subequal in length, as displayed by *B. changjini*, *B. uramurdahensis* and *B. leijsi*, or by *B. clayi*, *B. jundeeensis*, *B. parooensis*, *B. eberhardi*, *Br hahni* and *B. pilbaraensis*. In this context, the penultimate segment being significantly longer than the distal segment in *B. magna* is a peculiar feature. The outer margin of the third segment having two setae in *B. clayi* is also remarkable because it carries only one seta in the nine other species and in *Billibathynella* Cho, 2005 including the species with the largest body size, *Billibathynella humphreysi* Cho, 2005. The other peculiarity is the distal segment, which carries three setae (*B. clayi*, *B. jundeeensis*, *B. parooensis*, *B. eberhardi* and *B. leijsi*) or four setae (*B. magna*, *B. changjini*, *B. uramurdahensis*, *B. hahni* and *B. pilbaraensis*) including one plumose seta. In *B. parooensis*, *B. eberhardi* and *B. hahni*, this plumose seta could be as long as (*B. eberhardi*) or longer than (*B. parooensis* and *B. hahni*) the longest simple seta, while seven remaining species have a shorter one. The relative length of the plumose seta to the simple setae in *B. parooensis*, *B. eberhardi* and *B. hahni* seems to be size-independent. It is as yet uncertain whether the number of setae on the distal segment is a size-dependent character.

Labrum

The number of teeth on the free margin of the labrum varies from 12 (*B. hahni*) to 27 (*B. uramurdahensis*) and is generally correlated with body size. A remarkable deviation in this correlation is displayed by *B. magna*, which has the largest body size, yet only has 18 teeth.

Mandible

The number of teeth of the incisor process varies from four (*B. hahni* and *B. pilbaraensis*) to seven (*B. magna* and *B. changjini*) and that of spines in the spine row from five (*B. hahni* and *B. pilbaraensis*) to 20 (*B. uramurdahensis*). The spine row with 20 spines in *B. uramurdahensis* is remarkable, insofar as the species with the largest body size, *Billibathynella humphreysi*, has only 14 spines.

Maxillule

The distal segment of the maxillule carries five spines in *B. hahni* and *B. pilbaraensis*, which have the smallest body size but seven spines in the eight remaining species.

Maxilla

The number of setae of four individual segments varies 3–8/3–7/7–22/7–24 between species and is generally dependent on body size. Third and fourth segments carrying more

than 20 setae are unknown within Parabathynellidae. This condition, displayed in *B. uramurdahensis*, deviates from the correlation between body size and setal number.

Thoracopods I–VII

The number of basipodal setae of thoracopod I, the number of exopodal segments of thoracopods I–VII and the number of setae on the four endopodal segment of thoracopods I–VII are generally correlated with body size of species. This correlation is more evident if the conditions in *B. clayi* and *B. uramurdahensis* are not considered. The body size of these two species is similar to that of *B. jundeeensis*, but the former species has fewer endopodal setae and exopodal segments than *B. jundeeensis*, whereas the latter species is richest in endopodal setae and in exopodal segments of all 10 new species. A noticeable character, which seems to be independent of body size, is the presence of two setae on the dorsal margin of the second endopodal segment. This condition is displayed in thoracopod I–VII of the largest species, *B. magna*, and in the thoracopod II–VII of *B. uramurdahensis* and *B. parooensis* as well as in thoracopod II–VI of *B. eberhardi*, which has a relatively small body size.

Male thoracopod VIII

The male thoracopod VIII of the 10 new species is rectangular in frontal view and oval in lateral view. The relative length to width varies from 1.2 : 1 (*B. magna*) to 2.0 : 1 (*B. uramurdahensis*, *B. jundeeensis*, *B. parooensis* and *B. hahni*). The exopod usually has two subterminal setae with the exception of *B. hahni* (without seta) and *B. uramurdahensis* (three setae) and is distally dentate with the exception of *B. magna*, *B. jundeeensis* and *B. pilbaraensis*. The endopod is as large as the exopod in *B. magna*, *B. uramurdahensis*, *B. jundeeensis*, *B. eberhardi* and *B. leijsi*, two-thirds as large as the exopod in *B. changjini* and half as large as the exopod in *B. clayi*, *B. parooensis* and *B. hahni*. The presence of ctenidia on the protrusion of the basipod in *B. clayi* is remarkable.

Pleopod I

Pleopod I is either absent (*B. changjini*, *B. jundeeensis* and *B. leijsi*) or present (seven remaining species) independent of body size. If present, the pleopod I has either one or two setae dependent on the body size of each species. Interestingly, both right and left pleopods are attached closely only in *B. magna*, whereas a gap (*B. uramurdahensis* sp. nov. and *B. changjini* sp. nov.) or a distinct space (four remaining species with the first pleopod) is present between the bases of both pleopods in other species.

Uropod

Quantitative characters present on uropod are more (number of spines on sympod) or less (number of spines on endopod and number of setae on exopod) correlated with the body size of each species. The relative length of the endopod to exopod and the relative size of spines on the inner margin of endopod to the (sub-)terminal ones are the characters by which the species are distinguished qualitatively. For instance, the endopod is shorter than the exopod in *B. magna*, *B. changjini*, *B. uramurdahensis*, *B. jundeeensis*, *B. parooensis* and *B. leijsi*, whereas the reverse is true in *B. clayi* and *B. hahni* and the endopod and the exopod are of similar length in *B. eberhardi* and *B. pilbaraensis*. The spines on the inner margin of the endopod are very small, barely reaching the basis

of the terminal spine in *B. parooensis* and *B. eberhardi*, but not so small, exceeding half the length of the terminal spine, in the eight remaining species. A peculiar feature is the uropodal sympod of *B. uramurdahensis* which has inhomonomous spines.

Distribution

Except for *B. hahni* and *B. pilbaraensis*, the species described here and in Cho, Park and Ranga Reddy (2006) are from the northern Yilgarn craton, which forms, together with the Pilbara craton and associated orogens, the Western Shield of Australia that has been emergent since the Proterozoic. Inland palaeodrainages in the Yilgarn contain chains of salt lakes (playas) (Figure 41, see also Table 9) each representing the groundwater discharge of the local hydrogeological system (groundwater base level). Groundwater calcretes form immediately upstream of the salt lakes and each represents an isolated shallow calcareous aquifer the karstic features of which support a rich community of obligate groundwater animals (stygobionts). The development, characteristics and distribution of these calcretes is discussed elsewhere (Humphreys 1999, 2001; Humphreys et al. 2009).

The nature of the subterranean fauna of the region was described by Humphreys (2008), and the relationships of some taxonomic groups have been described, e.g. Parabathynellidae (Guzik et al. 2008), Oniscidea (Cooper et al. 2008), Amphipoda (Cooper et al. 2007; Bradford et al. 2009), Dytiscidae: Coleoptera (Cooper et al. 2002; Leys et al. 2003; Watts and Humphreys 2009; Guzik et al. 2009). These studies all show that each calcrete body supports a discrete assemblage of endemic stygobiont taxa. Although morphology suggests that some species of Parabathynellidae have populations allopatric between separate calcretes, e.g. *Atopobathynella wattsi* (Hinkler calcrete and Paroo calcrete; Cho, Humphreys and Lee 2006), no such case has yet been demonstrated using molecular methods (Guzik et al. 2008) and it would appear that the parabathynellids are generally restricted to single calcretes in the Yilgarn.

In the Pilbara, where *B. hahni* and *B. pilbaraensis* occur, the palaeodrainages still have strong, if episodic, floods, in contrast to those of the Yilgarn, where the palaeodrainages are largely dry. Groundwater in the Pilbara is typically fresh (Reeves et al. 2007), except in areas of inland drainage, even so, calcretes do occur extensively as lacustrine deposits (Poore and Humphreys 1998, 2003) and are associated with water gaps (Humphreys 2001) where *B. hahni* and *B. pilbaraensis* occur, respectively. The development, characteristics and distribution of these Pilbara calcretes is discussed elsewhere (Poore and Humphreys 1998, 2003; Humphreys 2001). The subterranean fauna in the context of the region was described by Eberhard et al. (2005) and the relationships of some taxonomic groups have been described, e.g. Ostracoda (Karanovic 2007), Copepoda (Karanovic 2006), Amphipoda (Finston and Johnson 2004; Finston et al. 2004, 2007); Tainisopidae: Isopoda (Wilson 2003; Keable and Wilson 2006; Finston et al. 2009). These studies show that fine-scale deep structuring occurs within taxa and/or local endemicity within calcretes.

Biology and habitat

The remainder of the *Brevisomabathynella* spp. was sampled from discrete, but widely distributed, calcrete deposits (Figure 41) of the northern Yilgarn region where groundwater in the calcretes is, typically, strongly salinity stratified with salinity

Table 9. Sampling sites of the ten new species of the genus *Brevisomabathynella* Cho, 2006. All the species are from Western Australia, Australia.

Sampling sites / species	(Palaeo-)drainage	Description of sites	Coordinates
Br. magna	Nabberu	Cunyu Station Site 272 Sweetwaters-Well	25°36'38"S, 120°22'21"E
Br. changjini	Carnegie	Lorna Glen Station Bore Site 42	26°15'31"S, 121°24'15"E
Br. clayi	Carey	Millbillillie Station, drainage between Lake Violet and Uramurdah calcretes, MEB site 266	26°41'15"S, 120°18'10"E
Br. uramurdahensis	Carey	Millbillillie Station, Uramurdah Lake, MEB site 264	26°41'15"S, 120°20'18"E 26°41'15"S, 120°21'11"E
Br. jundeeensis	Gascoyne	Jundee Station, JSP 10, South Hill Well BF, Jundee Mine	26°16'58"S, 120°40'33"E 26°21'22"S, 120°38'56"E 26°16'58"S, 120°40'33"E 26°17'14"S, 120°40'16"E 26°16'58"S, 120°40'33"E
Br. parooensis	Carey	Paroo Station GSWA 15 South	26°24'01"S, 119°45'47"E
Br. eberhardi	Carey	Paroo station, GSWA Bore #20(A)	26°20'44"S, 119°35'22"E
Br. leijsi	Nabberu	Cunyu Station, SBF calcrete, MEB site 36	25°46'51"S, 120°06'27"E
Br. hahni	Pilbara	Millstream aquifer, piezometer 15B	21°44'35"S, 117°14'30"E
Br. pilbaraensis	Pilbara	Ethel Creek, Bore W230	23°13'S, 119°54'E

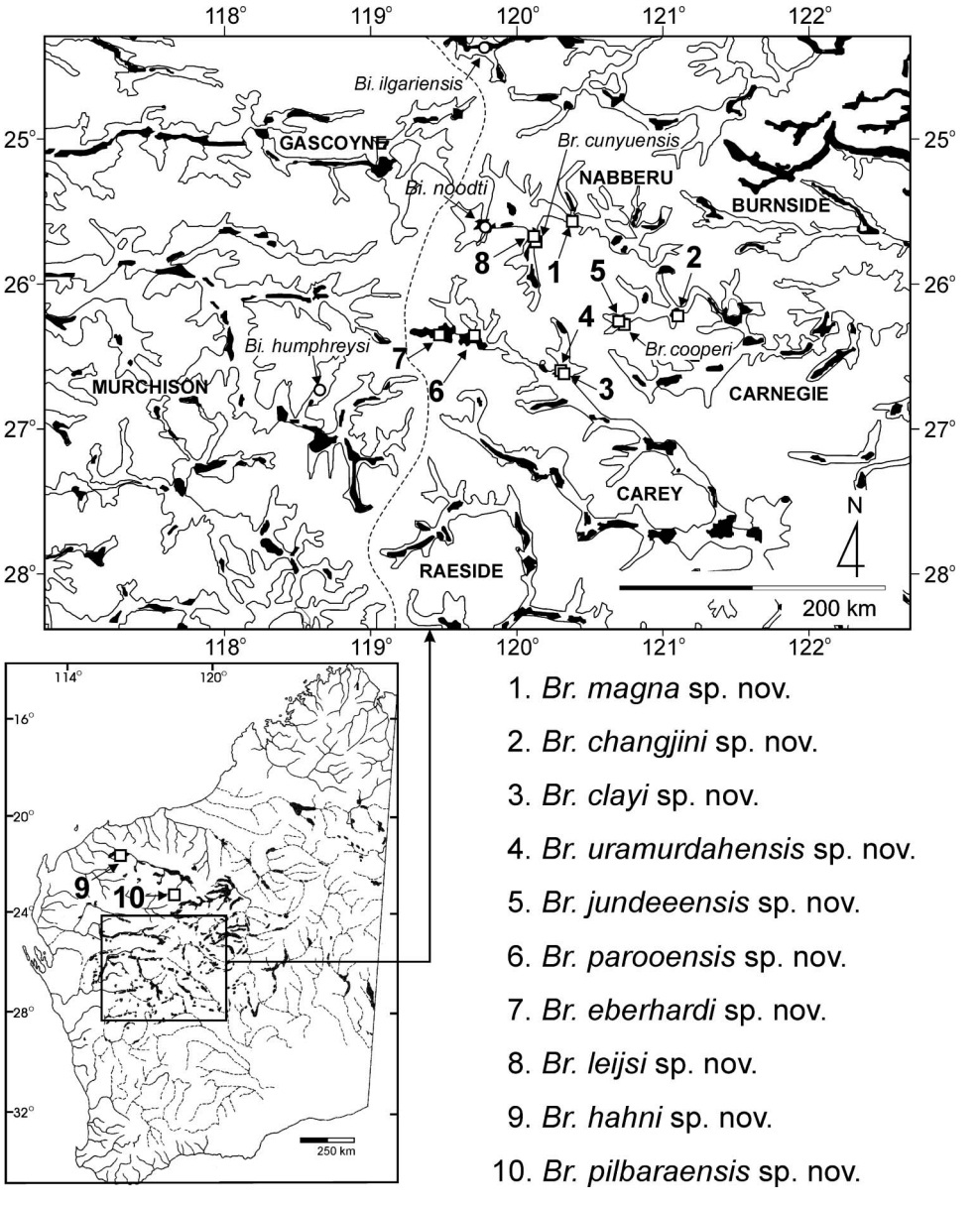

Figure 41. The distribution of the 10 new species of the genus *Brevisomabathynella* in the arid region of Western Australia. Sites 10 and 9 are respectively 270 km north and 535 km north-west of site 1.

ranging variously from freshwater to hypersaline conditions. Typically, sampling was from bores (tube wells) established for mineral exploration, for groundwater extraction or monitoring, or, occasionally, from shallow, manually excavated, pastoral wells. Consequently, few observations are known of their biology and behaviour. *Brevisomabathynella* species are associated with a rich but as yet incompletely known stygofauna which, at any calcrete, is largely endemic to that calcrete (Table 10).

Table 10. Stygofauna identified from the same calcrete deposits as given species of *Brevisomabathynella*.

Brevisomabathynella species	Associated fauna
B. magna Nabberu Palaeodrainage, Cunyu Station Site 272 Sweetwaters-Well	Cyclopoida (Copepoda); Candonidae: Candoninae (Podocopida); Hyalidae (Amphipoda); *Limbodessus sweetwatersensis* Watts and Humphreys, *L. cunyuensis* Watts and Humphreys, *L. silus* Watts and Humphreys (Dytiscidae).
B. changjini Carnegie Palaeodrainage, Lorna Glen Station Bore Site 42	*Nitocrella absentia* Karanovic (Ameiridae); *Schizopera jundeei* Karanovic, *S. uramurdahi* Karanovic (Diosacchidae); Podocopida. *Limbodessus lornaensis* Watts and Humphreys (Dytiscidae)
B. clayi and *B. uramurdahensis* Carey Palaeodrainage, Millbillillie Station, Uramurdah Lake, MEB site 264	*Gomphodella glomerosa* Karanovic (Limnocytheridae: Podocopida); *Halicyclops kieferi* Karanovic, *Mesocyclops brooksi* Pesce, De Laurentiis and Humphreys (Cyclopoida); *Nitocrella trajani* Karanovic, *Parapseudoleptomesochra karamani* Karanovic, *P. rouchi* Karanovic (Ameiridae); *Andricophiloscia pedisetosa* Taiti and Humphreys (Philosciidae); *Haloniscus longiantennatus* Taiti and Humphreys; *H. stilifer* Taiti and Humphreys; *Haloniscus* sp. 14 (Scyphacidae: Onsicidea); Hyalidae, Crangonictoidea (Amphipoda); *Limbodessus insolatus* Watts and Humphreys; *L. hahni* Watts and Humphreys; *L. morgani* Watts and Humphreys (Dytiscidae).
B. jundeeensis and *B. cooperi** Gascoyne, Jundee Station, JSP 10, South Hill Well BF, Jundee Mine	*Halicyclops kieferi* Karanovic (Cyclopidae); *Schizopera jundeei* Karanovic (Diosacchidae); *Limbodessus jundeeensis* Watts and Humphreys (Dytiscidae)
B. parooensis and *B. eberhardii* Carey Palaeodrainage, Paroo Station GSWA 15 South	Phreodrilidae (Oligochaeta); *Candanopsis williami* Karanovic and Marmonier (Candonidae: Candoninae). *Halicyclops kieferi* Karanovic, *H. eberhardi* De Laurentiis, Pesce and Humphreys, *Metacyclops* cf. *monacanthus* Kiefer, *M. laurentiisae* Karanovic, *Microcyclops varicans* Sars (Cyclopidae); *Australocamptus diversus* Karanovic (Canthocamptidae: Harpacticoida); Crangonyctoidea (Amphipoda); *Limbodessus kurutjutu* Watts and Humphreys, *L. eberhardi* Watts and Humphreys, *L. pulpa* Watts and Humphreys (Dytiscidae).

(*Continued*)

Table 10. (Continued).

Brevisomabathynella species	Associated fauna
B. leijsi and *B. cunyuensis** Nabberu Palaeodrainage, Cunyu Station, SBF calcrete, MEB site 36	Candonidae: Candoninae (Podocopida). Cyclopoidea. Hyalidae (Amphipoda); *Limbodessus macrotarsus* Watts and Humphreys, *L. bialveus* Watts and Humphreys (Dytiscidae).
B. hahni Pilbara, Millstream aquifer, piezometer 15B	Phreodrilidae (Oligochaeta); Candonidae: Candoninae (Podocopida); *Mangkurtu mityula* Poore and Humphreys (Spelaeogriphacea); *Pilbarus millsi* Bradbury and Williams (Amphipoda); *Tiramideopsis lictus* Harvey (Mideopsidae: Acarina).
B. pilbaraensis Pilbara, Ethel Creek, Bore W230	Enchytraeidae, Phreodrilidae (Oligochaeta); *Origocandona gratia* Karanovic, *Neocandona newmani* Karanovic, *Pilbaracandona colonia* Karanovic and Marmonier, *P. eberhardi* Karanovic and Marmonier (Candoninae: Candonidae); *Mesocyclops brooksi* Pesce et al., *M. varicans* Sars, *Tropocyclops prasinus* Fischer, *Diacyclops humphreysi humphreysi* Pesce and De Laurentiis, *D. sobeprolatus* Karanovic, *D. cockingi* Karanovic, *Fierscyclops* (*Pilbaracyclops*) *supersensus* Karanovic (Cyclopidae); *Archinitocrella newmanenesis* Karanovic (Ameiridae); *Pygolabis humphreysi* Wilson (Tainisopodidae: Isopoda). †*Chydaekata acuminata* Bradbury, †*C. anophelma* Bradbury, †*C. brachybasis* Bradbury, †*C. breviclava* Bradbury, †*C. carscutica* Bradbury, †*C. diagonalis* Bradbury, †*C. dolichodactyla* Bradbury, †*C. gyraspis* Bradbury, †*C. nudula* Bradbury, †*C. ovatosetosa* Bradbury, †*C. scopula* Bradbury, †*C. scuticara* Bradbury, †*C. simulata* Bradbury, †*C. transversa* Bradbury (Paramelitidae: Amphipoda)

Notes: *Species described in Cho, Park and Ranga Reddy 2006.
†The 14 species of *Chydaekata* described by Bradbury (2000) from this aquifer have proven problematic (Finston et al. 2004). Although they are not formally refuted, molecular and morphological work over a broad area of the Pilbara has established the genus as widespread (Finston et al. 2007), comprising a number of cryptic species, some of which are sympatric (Finston and Johnson 2004; Finston et al. 2007).

Water quality data for four sites (Table 11) show chemically stratified water columns, near neutral pH, as expected in carbonate substrate, and temperatures reflecting the mean annual temperature of the region. The sampling method used,

Table 11. Water quality with depth for various species of *Brevisomabathynella*.

Species site	Depth (m)	Temperature (°C)	pH	Salinity (%)	DO (mg/l)	ORP (mV)
B. changjini	– 0.1	28.39	7.3	8.08	3.56	107
7 May 2005	– 1.1	27.25	7.18	8.16	4.12	110
Carnegie Palaeodrainage, Lorna Glen Station Bore Site 42	– 1.7	27.06	7.14	8.17	4.03	111
B. leijsi	– 0.1	26.92	7.21	3.52	4.84	99
6 May 2005	– 1.1	26.56	7.18	3.53	4.87	100
Nabberu Palaeodrainage, Cunyu Station, SBF calcrete, MEB site 36	– 2.1	26.24	7.06	4.52	3.50	102
	– 3.1	26.05	6.88	7.2	1.53	91
	– 4.1	25.94	6.69	11.86	0.41	– 11
	– 5.2	25.94	6.56	15.82	0.32	– 95
	– 6.1	25.94	6.52	18.11	0.26	– 137
	– 7.1	25.96	6.52	19.27	0.27	– 147
	– 8.1	25.99	6.56	20.03	0.28	– 162
B. clayi	0	21.68	7.64	35.93	5.25	137
3 June 2004	– 0.2	24.75	7.31	34.92	2.96	145
Carey Palaeodrainage, Millbillillie Station, drainage between Lake Violet and Uramurdah calcretes, MEB site 266	– 3	24.75	6.8	46.79	0.85	154
	– 4.6	24.48	6.51	59.01	0.23	158
B. uramurdahensis	– 0.1	26.22	7.28	5.94	2.31	89
3 June 2004	– 2	26.05	7.1	7.01	0.61	92
Carey Palaeodrainage, Millbillillie Station, Uramurdah Lake, MEB site 264	– 3	25.89	7.09	7.12	1.58	93
	– 3.5	25.85	7.09	7.18	2.38	93
	– 4.1	25.79	7.1	7.49	4.30	96
	– 5.5	25.71	6.92	13.75	4.81	105
	– 6	25.69	6.75	24.4	3.00	113
	– 7	25.67	6.56	39.25	0.96	117
	– 8	25.66	6.48	59.38	1.26	119
	– 8.4	25.66	6.45	69.45	1.23	118

Notes: DO, dissolved oxygen; ORP, oxidation reduction potential.

hauling a net through the water column, precludes information on the natural location of individual parabathynellids within the water column. However, the data for *B. clayi* at one site (Table 11) show a surface salinity of 35%, a site also inhabited by *B. uramurdahensis*. At another location the stratification of the water column was such that the surface water was close to seawater salinity, increasing with depth, and so the minimum salinity inhabited at this location was at least 30% (Figure 42). This location is inhabited by *B. uramurdahensis* and *B. clayi* and other stygal taxa, and has maintained a similar water profile when intermittently sampled over a period of 9 years. Hence, at least two *Brevisomabathynella* species

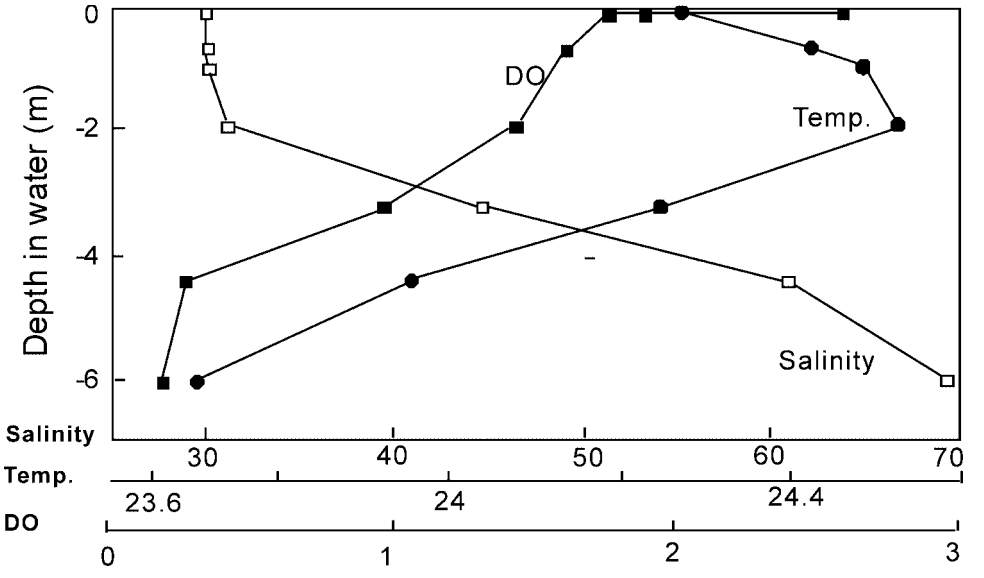

Figure 42. Water quality variation with depth in groundwater in Uramurdah calcrete at site 261. Salinity (%) Temp. (temperature, °C), DO (dissolved oxygen, mg/l). (after Humphreys, 2006). As well as *Br. clayi* and *Br. uramurdahensis*, this site also supports stygal oniscideans, harpacticoid copepods, amphipods, and dytiscid diving beetles.

are able to sustain populations at near-seawater salinity, at a location that is now 600 km from the present Indian Ocean and in the centre of a land mass emergent since the Proterozoic.

In these situations the bathynellids often occur swimming in the water column in great numbers. For example, 160 *Atopobathynella wattsi* were collected in a single haul of the net through the water column of an unused water supply bore on 22 May 1999 in the Hinkler Well calcrete. This drains to the same salt lake as the Uramurdah and Lake Violet calcretes (Millbillillie station), and is in the same palaeodrainage system as the Paroo calcretes, all of which contain *Brevisomabathynella* spp. The median number of *Brevisomabathynella* taken in 63 samples was two with a maximum number of 27 (mean 3.8; standard deviation 4.46). Observations in 1999 of a small aquarium in daylight, and by video at night under subdued illumination, showed the spindle-shaped fat-bellied *B. uramurdahensis* from Uramurdah calcrete swimming strongly for prolonged periods, twisting and turning with facility in the open water.

Sympatric *B. uramurdahensis* and *B. clayi* are closely matched in size at 3.62 mm and 3.52 mm total body length, respectively. This is in contrast to sympatric species of stygal Dytiscidae which are typically well separated in size (summarized in Watts and Humphreys 2009). Examination of several attributes of four sympatric species pairs of *Brevisomabathynella* in the Yilgarn shows that those most closely matched in body size have quite different body forms (Table 12). Those with similar morphology that are closest in size (*B. parooensis* and *B. eberhardi*) differ in length by 10% which scales to a mass difference of 33%, that expected from basic niche separation theory (Kobayashi

Table 12. Attributes of four sympatric species pairs of *Brevisomabathynella*.

Sympatric *Brevisomabathynella* species	Respective total length (mm, holotype); % large to small	Respective length/width	Respective body form
B. uramurdahensis, B. clayi	3.62, 3.52; 103	10–22.6, 11	fat-bellied, long narrow
B. jundeeensis, *B. cooperi*	3.42, 1.72; 199	10, 4.5	long narrow, squat*
B. parooensis, *B. eberhardi*	2.01, 1.82; 110	10, 10	long narrow, long narrow
B. leijsi, *B. cunyuensis*	1.72, 1.72; 100	11, 4.5	long narrow, squat*

Note: *Morphologically, these species indicate predatory feeding and observation on these species has established predation for the first time in Parabathynellidae, the specific prey being an ostracod (Cho, Park and Ranga Reddy 2006).

1995; Churchfield et al. 1999; Ganeshaiah et al. 1999) but much less than the linear difference between three comparisons of sympatric species pairs of *Limbodessus* (Dytiscidae) from the same calcretes (range 37–67%) recorded in Watts and Humphreys (2009).

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